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TWENTY-SEVENTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
University Park, Pennsylvania

1963

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1963

Twenty-seventh Annual Report
of
Pasture Research
in the
Northeastern United States

U. S. Regional Pasture Research Laboratory
University Park, Pennsylvania
Forage and Range Research Branch
Crops Research Division,
Northeast Branch
Soil and Water Conservation Research Division,
and
Grain and Forage Insects Research Branch
Entomology Research Division
of the
Agricultural Research Service
U. S. Department of Agriculture
and
The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

For Administrative Use Only

B.

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* * * * *
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PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This report, the twenty-seventh in the series, was prepared by and is intended primarily for use of personnel engaged in forage research in the twelve Northeastern States. It contains a summary of progress during 1963, reflects an appraisal of problems and provides information that should benefit all co-operating states. Included are reports from research scientists at the U. S. Regional Pasture Research Laboratory, from the northeast forage crops technical committees, from research workers at the state experiment stations and from personnel of the Forage and Range Research Branch and the Grain and Forage Insects Branch, Beltsville, Maryland.

Collaborators assembled materials from their respective stations, chairmen of regional technical committees supplied reports of their activities on forage problems and scientists at the Pasture Research Laboratory and leaders at Beltsville prepared reviews of their forage research related to this region.

In February Dr. D. K. Barnes transferred to Mayaguez, Puerto Rico and remains with the Crops Research Division. Mrs. Amina Birkenmayer replaced Mrs. N. Dawn Neidigh as typist.

Climate at State College and Cooperative within the Region

Monthly precipitation at State College was appreciably below normal during each of 9 months in 1963. November was the only month when it was normal or above. Soil moistures in early spring were near field capacity but in May were appreciably lower and ranged between 10 and 26% available moisture. During June, moisture was moderate, ranging between 25 and 30% but thereafter, July-September inclusive, dry conditions occurred with less than 10% available soil moisture at depths of 4, 8, 12 and 16 inches beneath a clipped bluegrass sod.

Precipitation in the several states in the region was variable and limited growth at all locations during June and July. November was the only month when precipitation was above normal in all states ranging from +1.33 in Vermont to +4.16 in New Jersey.

Monthly mean air temperatures at all states were much below normal during January, February and December and appreciably above normal during March, October and November. Daily snow cover during the months of December through March ranged between 8 and 10 inches in Pennsylvania, 9 and 13 inches in New York and 8 and 21 inches in Vermont. Soil temperatures at 4-inch depths ranged between an extreme of 27° in February in Pennsylvania to a high of 79° in Maryland during July. Daily mean soil temperatures in all states were generally between 30 and 40 degrees at all depths during November to April inclusive. The daily sunshine received averaged approximately 65% of the total possible during April to October inclusive while during March and November only 25% of the total possible occurred.

Relative humidities at noon averaged approximately 33 and 35% during April and October and 51 and 57% during June and August.

At State College a severe frost 29°F May 24 damaged grapes, peaches and apples without severe injury to forage. Dates of spring freezes within the Northeast ranged from an earliest last freeze on March 19 in New Jersey to a latest fall freeze on November 25, also in New Jersey (Table 1).

Table 1. Last temperature of 28°F or below in the spring and the first temperature of 28°F or below in the fall (1963).

	<u>Last in spring</u>		<u>First in fall</u>		Days between
	Date	Temp.	Date	Temp.	
Main	5/13	27°	9/14	28°	123
Vt.	5/3	28°	9/24	23°	143
Conn.	4/6	28°	11/15	28°	222*
R. I.	4/29	28°	9/25	28°	150
N. Y.	5/24	27°	9/24	26°	122
Pa.	4/5	28°	11/24	26°	232**
N. J.	3/19	28°	11/25	25°	250
Md.	3/23	28°	11/13	27°	234

* September data missing.

** Killing frost 5/24 - min. temp. 29°.

RESEARCH AT THE PASTURE LABORATORY

GENETICS, PATHOLOGY AND ENTOMOLOGY

Alfalfa

Development of Disease Resistance in Alfalfa

By a modified backcross program, disease resistance to two foliar diseases was introduced into Vernal alfalfa (1962 Annual Report, p. 3). Polycross nurseries (seed produced from selected clones) were established at 3 locations to determine relationships between forage and seed yields and to evaluate for general combining ability. Observational plantings were established in New York, Indiana, and Nebraska.

There appears to be little correlation between seed yield of clones in Utah and the number of selfed seed produced in the greenhouse at the Pasture Research Laboratory.

Recurrent Selection for Resistance to Common Leaf Spot
in Alfalfa Mass-selection Populations MSA and MSB

Recurrent phenotypic selection in three cycles from two broad-based genetic populations was successful in isolating and concentrating resistance to Pseudopeziza medicaginis (1962 Annual Report, p. 3). The percent of plants rated resistant increased in population MSA from 4% (original population) to 44% to 75% and in population MSB, from 8% to 55% to 87%. The reliability of the inoculation procedure was substantiated.

The frequencies of eight abnormal seedling characters (crinkle cotyledon, circle cotyledon, yellow cotyledon, single cotyledon, three cotyledons, four cotyledons, no primary leaf, and two or more primary leaves) were observed in each generation to get an estimate of genetic change in the two populations. Some seedling characters remained stable while others dropped in frequency during three cycles.

Selections from Connecticut with Resistance to
Bacterial Wilt and Crown and Root Rots

(In cooperation with D. D. Wolf, Connecticut Experiment Station, Storrs).

A study is underway to develop material with resistance to crown and root rotting agents as well as to Corynebacterium insidiosum. In 1958, surviving plants from a polycross progeny test seeded in 1951 in Connecticut were intercrossed at the Pasture Laboratory. Plots were established at Storrs, Conn. in 1959 and in Penna. in 1962. Best selections in the Conn. planting in 1963 averaged 90%

survival while Vernal averaged 35% and DuPuits, 15%. In the Penna. planting all selections were resistant to bacterial wilt. Most DuPuits and Narragansett plants had died by fall 1963.

Some crosses were resistant to Pseudopeziza medicaginis. Reactions to P. medicaginis in greenhouse inoculations and in the field (natural infection) appeared to be correlated.

Root and Crown Rot

When autoclaved infested soil was used as inoculum, Fusarium oxysporum medicaginis from alfalfa caused xylem necrosis, stunting, and death of DuPuits alfalfa plants inoculated in the greenhouse. Clipping roots of 3-month-old plants before transplanting did not result in more xylem necrosis than not clipping. Small rootlets, however, were broken during transplanting. After 10 weeks, 83% of unclipped and 79% of plants with clipped roots had severe xylem necrosis of taproots. Little cortical rot developed. Results indicate (1) that severe wounding is not necessary for invasion of plant roots and (2) that this fungus is systemic in its action and not a cortical pathogen. The prevalence of F. oxysporum medicaginis (normally a southern pathogen) in the Northeast is not known.

The effect on seedling growth and root disease development of incubation periods of F. oxysporum medicaginis in autoclaved soil prior to planting was studied in two experiments. After 10 weeks the average severity of cortical root rot and xylem necrosis was greatest, and weight of oven-dried seedlings was lowest, where the fungus was incubated in the soil from 2-6 days prior to planting. Only a trace of xylem necrosis was found on seedlings grown in uninfested soil.

Red Clover

Selection for Persistence of Red Clover

A program has been underway at the Pasture Laboratory for the past 12 years to develop lines of red clover with "genes" for persistence. After 4 cycles of selection, some lines averaged 20-40% ground cover in July after surviving two winters, while Pennscott, Kenland, and Lakeland averaged 9, 3, and 1%, respectively. This material is available to plant breeders as clones or as remnant seed.

Effect of Pesticides on Persistence of Red Clover

In a 3 1/2-year field experiment in which red clover was sprayed frequently with fungicides and insecticides, the former did not reduce the incidence of root and crown rot. Plants in plots receiving insecticides had little root damage from the root borer and root curculio and also had approximately

one-half the number of plants showing virus symptoms as plants in check plots or fungicide-sprayed plots. The application of insecticides resulted in a significant decrease of root and crown rot and a significant increase in growth and ground cover of red clover. During the 3 1/2 years of the study the incidence of internal breakdown (a physiogenic disease) was similar in all treatments.

Internal Breakdown (IB) of Red Clover

In F₅ crosses (1962 Annual Report, p. 5) of non-IB X non-IB plants, 15% of the progenies developed IB. The crosses ranged from 0 to 39% incidence of IB. Nonselected Pennscott averaged 71%.

Root and Crown Rot

In greenhouse inoculations Pennscott seedlings showing virus symptoms (bean yellow mosaic) developed more cortical root rot when inoculated with Fusarium oxysporum than seedlings having no visible virus symptoms.

Disease Susceptibility of a Trifolium Hybrid

Intercrosses from [(Trifolium pratense X T. diffusum) X T. pratense] were obtained from The Pennsylvania State University (Schwer, a former graduate student in Agronomy). Seeds of 38 entries were planted in 4" pots in the greenhouse in November 1962. Some plants were inoculated with Stemphylium botryosum, Leptosphaerulina trifolii, and Erysiphe polygoni (powdery mildew). All plants were examined for internal breakdown (IB) when 5-7 months old.

Plants of the hybrid were susceptible to the three fungi. The incidence of IB varied from 0 to 100% after 7 months. The average was 44% compared with 71% for seedlings of Pennscott.

Bromegrass

Selections with Leaf Disease Resistance

Polycross progenies of 15 brome clones inoculated as seedlings in growth chambers with suspension of Helminthosporium bromi varied in their resistance. At least 90% of progenies from 2 clones were resistant to Helminthosporium and also showed a high level of resistance to subsequent inoculation with Stagonospora bromi. Polycross progeny tests established at University Park and at Durham, N. H. will be used to evaluate field resistance to these organisms and to scald, Rhynchosporium secalis.

Brown Stripe (Scolecotrichum graminis) of Grasses

Methods have been developed to induce Scolecotrichum graminis to sporulate in culture and to produce the disease freely in the greenhouse. Isolates from orchardgrass attacked only orchardgrass and isolates from tall oatgrass infected only that species. Isolates from both grasses differed little in conidial morphology and in cultural characteristics.

Effects of Location on Meiosis of Bromegrass

Microspore quartets in 10 clones of smooth brome were examined for presence of micronuclei as a measure of meiotic irregularities. Data showed no difference among 5 locations in the western United States. Mean numbers of micronuclei in quartets among 6 brome clones grown at Logan, Utah, were statistically different, but the means for 2 sampling dates did not differ. The negative correlation, $r = -0.54$, between quartets with micronuclei and the average maximum temperatures 2 days before dates of fixation was highly significant, but factors other than temperature appeared to have greater influence on meiotic irregularities. Presence of micronuclei in quartets appeared to be unrelated to seed potential of the clones under study.

Orchardgrass

Breeding Improved Orchardgrass

One polycross progeny test was reseeded in April at 2 locations owing to unsatisfactory establishment of the nurseries seeded in 1962. The 1962 polycross nursery of medium-late orchardgrass is expected to yield seed in 1964 for progeny testing in 1965.

Twelve selected clones which had failed to flower previously over 2 successive years at University Park and which had responded differently to floral induction treatments in the greenhouse were arranged in 3 separate 4-clone synthetic combinations and established at Prosser, Washington, in randomized blocks with 10 replicates. Seed yields from the 3 synthetics, Syn A, Syn B, and Syn C, the year following establishment were, respectively, 2,650 g, 1,220 g, and 1,080 g. The nonsignificant correlation between mean number of heads per plant and seed yield was $r = 0.48$, $n = 12$. Two plantings established in 1962 at the Musser Farm, 5 miles east of the Pasture Laboratory, suffered from drought over 2 years. Clones 61-4, 61-12, and 61-20 flowered sparsely in one planting and had no heads in the other. All clones flowered in the planting adjacent to the Laboratory where water was applied as needed in 1962 and 1963.

Effects of Locations on Meiosis of Orchardgrass

Micronuclei in microspore quartets as a measure of meiotic irregularities of 8 clones were found not to vary among 4 locations in the western United States. Differences in quartets with micronuclei among 7 clones at Logan, Utah, and among 3 fixation dates were highly significant. Contrary to expectation of a negative correlation, a significant positive correlation, $r = 0.40$, resulted when micronuclei in orchardgrass were compared with temperatures of 2 nights before dates of fixation. Factors other than temperature appeared to have greater influence on meiotic irregularities. Presence of micronuclei in quartets appeared to be unrelated to seed potential of the material studied.

Ryegrass

Interspecific Hybridization and Genome Analysis

As part of the study of hybridization in Lolium, chromosomes in meiosis were analyzed for parental species. Occasional L. rigidum plants had extra chromosomes either as accessory chromosomes or as fragments. In general meiosis was regular for the parental species, but extra chromosomes of unknown origin were recorded in meiotic cells of F_1 plants having $2n = 14$ chromosomes in root meristems. Others also had additional chromosomes in root cells. The F_2 generation from 6 crosses was obtained by selfing or intercrossing F_1 plants. Sporocytes from randomly chosen plants will be examined for chromosome associations and the seed set from these plants will be determined. Additional F_1 hybrids resulted from these crosses: L. perenne X L. rigidum, L. multiflorum X L. rigidum, and L. multiflorum X L. persicum.

The taxonomic identification of the accessions used in these studies was made by Dr. E. E. Terrell at Beltsville, Md. He suggested that L. remotum should be treated as a variety of L. temulentum and that L. strictum was L. rigidum Gaud. (sens. lat.). The 3 accessions of L. strictum were found to be highly self-fertile in contrast to the self-incompatibility of several L. rigidum accessions. Fisher's discriminant function applied to 9 quantitative characters delimited the self-compatible L. remotum, L. strictum, and L. temulentum when compared with their interspecific hybrids to the self-incompatible L. rigidum. Paper chromatography of plant sap separated the species into 3 groups: (1) L. perenne, L. multiflorum, and L. rigidum; (2) L. temulentum, L. remotum, and L. persicum; (3) L. loliaceum. Chromatograms of interspecific hybrids between parents assigned to 2 different groups could be distinguished from those of the maternal parents. The chromatographic technique used in this study was less efficient than the biometric method in separating Lolium species.

Ryegrass-Fescue Intergeneric Hybrids

Breeding and Evaluation of Fertility and Persistence

Pollen and seed fertility were studied in hexaploid $2n = 42$ Lolium-Festuca hybrid clones and their progenies. Nonstainable pollen averaged 20.6% in 1962 but 41.8% in 1963. Correlation between the 2 years' estimates was low but highly significant, $r = 0.23$, $n = 440$. The correlation between 18 parent clones and the means of their open-pollination progenies was nonsignificant. Based on pollen and seed fertility, plant vigor, leaf disease resistance, and maturity, 97 plants were selected for further study. Three panicles per clone sampled for seed set after open-pollination as well as total seed weight per clone indicated relatively high seed fertility in several clones. Fifty vigorous clones, some of which were selected after progeny testing, were established by Dr. R. C. Buckner at Lexington, Ky., in a replicated, cafeteria-style grazing nursery. Results from this study and from polycross and single-cross progeny tests at University Park will be used as the basis for formulating several synthetic combinations. Syn 1 seed is expected to be available for forage plot trials in 1965.

Topcrosses were made in the greenhouse in 1962-63 between male-sterile and male-fertile Lolium-Festuca hybrid clones with $2n = 28$ chromosomes to study causes for pollen sterility. Additional tetraploid breeding material was obtained by intercrossing our LF hybrids, tetraploid meadow fescue, tetraploid annual ryegrass, and F_1 plants ($2n = 28$) between perennial ryegrass and tall fescue.

Studies on mutagenic effects of colchicine and ethylenedisulfate on persistence of tetraploid LF hybrids were advanced one generation by intercrossing 7 selected colchicine-treated plants, 10 treated with ethylenedisulfate, and 7 control plants. In addition to the 3 polycrosses, topcross progenies were obtained from 20 of the 24 clones. The established planting consisted of 5-plant rows of each entry in 3 replicates and totalled 760 plants, which will be evaluated for persistence in 1964. Additional LF hybrids treated with 2 levels of thermal neutrons, 30 min and 60 min, at Brookhaven National Laboratories will be examined cytologically for possible chromosome aberrations and survivors will be evaluated for persistence.

Cytogenetics of Kentucky Lolium-Festuca Materials

Chromosomes were counted for amphiploids of annual ryegrass-tall fescue hybrids from first, second, fourth and fifth increase generations where parents in each cycle were $2n = 56$. Chromosome instability was characteristic for each generation. For instance, 44 G_4 plants were $2n = 56$, 5 were $2n = 49$, and 2 were $2n = 42$.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Carbohydrate Studies on Forages

Studies on the hemicelluloses of forage plants are being continued (1962 Annual Report, p. 12). It was necessary to revise the quantitative procedure for the determination of total hemicellulose. The method is, in brief, to dissolve the entire cellulosic complex in 72 percent sulfuric acid, to dilute the acid to 1.0 N strength, to heat the mixture for several hours, and to determine the total nonfermentable reducing power in the hydrolizate. The value does not include any glucose derived from the hemicellulose as the yeast does not distinguish between glucose from hemicellulose and glucose from cellulose, but the value represents a definite and reproducible entity. In alfalfa, hemicellulose (anhydride) ranged from 11.4 to 14.4 percent of the dry matter, about half the quantity of cellulose. In some legume silages the ratio between hemicelluloses and cellulose was about 0.41, indicating some loss of hemicellulose during silage fermentation. In grasses the percentages of hemicelluloses were greater than in legumes, averaging about 22 percent, except for timothy which contained over 25 percent. The ratio of hemicelluloses to cellulose was usually in excess of 0.7 in grasses. Preliminary results indicate that hemicelluloses have in most cases a lower digestibility than does cellulose.

Measurement of the Feeding Value of
Forages by Chemical Analysis

The object of these studies is to improve the prediction of digestibility from the chemical composition of the forage and to determine the error of the prediction. Forage samples of known digestion values were obtained from state experiment stations (through Regional Committee NE 24) and serve as the experimental material. Most satisfactory prediction of digestibility was obtained with some form of lignin or by some scheme of analysis which included a lignin determination. The chief difficulty has been in predicting the digestibility of both grasses and legumes from the same criteria. A tentative scheme (called the Summation Method) depends on the analysis for ash, ether extract, protein, alcohol-insoluble matter, alcohol-insoluble protein, and lignin. From these are calculated the digestion coefficients of four nutrients and their sum gives total digestible organic matter. Some results are given in Table 1. This scheme seems to be successful in predicting total digestible organic matter in both grasses and alfalfa. In 47 samples (36 grass and 11 alfalfa) the standard error of the prediction of digestible organic matter was 2.0. The method is more lengthy than the common proximate scheme but is being studied further with the object of reduction in time and labor.

Table 1. Some results of the prediction of total digestible organic matter by a Summation Method. The percentages of the nutrients are multiplied by their digestion coefficients to give the percentages of digestible nutrients. The sum of these gives total digestible organic matter in percent of organic matter, or, which is the same thing, the digestion coefficient of organic matter. The error is the difference between the digestibility calculated by this scheme and that determined with sheep.

Nutrient	Digestion coefficient	Percentage of digestible nutrients		
		Bromegrass	Kentucky bluegrass	Alfalfa
Ether extract	0.4 ^{/1}	1.2	1.7	0.8
Protein	Calc. ^{/2}	8.6	14.3	21.0
Alc.-sol. carb.	1.0 ^{/1}	16.4	21.8	14.2
Alc.-insol. carb.	Calc. ^{/3}	45.7	39.6	28.3
Sum		71.9	77.4	64.3
Error		+2.3	-1.6	-1.0

^{/1} Assumed values.

^{/2} Digestible protein was calculated from crude protein by the equation, $Y = -2.77 + 0.88 X$, then converted to organic matter basis.

^{/3} The digestion coefficient of the insoluble nonprotein fraction was calculated from the lignin content (method of Ellis et al.) by equation, $Y = 99.9 - 3.70 X$, Y being the digestion coefficient of the alcohol-insoluble nonprotein fraction and X being lignin in percent of the alcohol-insoluble fraction

Effects of Reserves, Light Intensities, and Heights of Cut on Dry Matter Production and Accumulated Energy in Seedlings of Orchardgrass

Work continued on growth responses of orchardgrass seedlings receiving different management treatments. Individual seedlings were established and grown in the greenhouse under two light intensities; 1) natural intensity, and 2) intensity reduced to 2/3 of natural by shading with cheesecloth. This provided groups of plants with two initial amounts and concentrations of accumulated

energy (reserves, carbohydrates). Subsequent treatments of plants within each group included cuttings made at 2 1/2 and 1 1/4 inches above soil level, which were allowed to regrow under the two light intensities used initially.

In this trial three primary objectives included: 1) clarification of relationships between the eight possible combinations of different managements on (1) production of dry matter, (2) evaluation of the effects of levels of initial reserves on subsequent growth, and (3) comparison of biological and chemical methods for measuring energy which had accumulated within plant tissue and still remained available for growth. By comparing dry matter production and accumulations of energy in relation to the treatments used it is evident that plants established under high light intensities had greatest yields and highest reserves. Plants grown under lower light intensities made less regrowth in the dark and also made less growth in the greenhouse. Subsequent comparisons of production by plants under various growth conditions suggest that the levels of energy accumulated initially affected later production as did subsequent heights of cut and light intensities. Continuation of various conditions to a third harvest emphasized the dynamic nature of plants' growth responses to immediate environments.

To measure significances of various treatments which had been provided in the greenhouse, a split-plot design was used with light intensities as the main plots, and with reserves and heights of cut as subplots. Following two 3-week growth periods differences in production could not be attributed solely to specific treatments such as initial levels of reserves, light intensities, or heights of cut. Interactions between treatments such as reserves X height of cut and light intensity X height of cut were paramount in determining amount of dry matter produced.

The reserves were measured by using both the chemical and biological methods. In the latter the dry matter produced by a plant grown in darkness was used as indicative of relative amounts of energy available. Previous chemical work with grasses indicated that high concentrations of carbohydrates occurred in the sheaths of leaves. Growth of grass in the dark also appears to be dependent on energy in leaf sheaths. Chemical measures of reserves frequently indicate percentage concentrations of carbohydrates at special locations whereas biological measures indicate relative amounts of energy from which new growth may arise. This is obtained and is then expressed as mg/tiller by dividing the weight of etiolated tissue produced by the number of tillers from which it was harvested.

Growth in darkness may also be expressed as the percentage of the initial weight which is recovered as new growth made in darkness. This expression is similar to chemical measures usually expressed as proportions or percentages. The initial weight of the plant parts must be assumed to be the sum of the weights of new tissue and the weight of plant parts remaining after growth in darkness has ceased. Errors may occur when decisions are made on whether dark growth originated from a specific part or whether this part may have been nonfunctional or contained no available energy at the time the sample was placed in darkness.

In this study good correlations were obtained between chemical and biological measures of reserves in similar plants (Table 1). Technical improvements are planned, particularly for increased accuracy and applicability to diverse species grown under various conditions. It is probable that the present biological method will be used most frequently where chemical facilities are least available.

Table 1. Correlation coefficients between reserves measured biologically and chemically (significant at 1% point).

1	% recovered and % sugar	$r = 0.82$
2	mg/pot and mg sucrose/pot	$r = 0.83$
3	mg/tiller and % sugar	$r = 0.85$
4	mg/tiller and mg sugar/tiller	$r = 0.90$

Growth and Energy Accumulation in Orchard-grass and Timothy Seedlings

In greenhouse studies measures were made of the rates of growth of orchard-grass and timothy seedlings under various management and environmental conditions after germination and during early establishment of the plants. Three light conditions were used which included long and short daylengths, and broken nights to simulate long days. Growth under each light treatment continued for periods of 39, 60, 81 and 103 days after emergence before clipping. The clipped plants were allowed to grow for 30 days while similar but uncut seedlings grew an additional 30 days. An objective in this trial was to measure effects of interruption of growth by clipping on the rate of plant establishment. Rates of growth were measured for the several intervals under the three light conditions, and indicate that appreciable increases in rates of dry production and energy accumulation (measured biologically) did not occur until after 60 days' growth. Comparisons of plants grown for three months with those which had been grown for a shorter time, or had been cut and allowed extra time for recovery, indicate that a continuous three-month period is advisable before cuttings of seedlings are made. Four months time for establishment is still better and particularly when fertility or climatic factors may limit growth. Critical comparisons are not available to measure specific effects of long and short days, but observations suggest that the early growth rates and accumulations of energy, were higher on plants which had received 5 hours of illumination per day even of low intensity radiation from filament lamps that were used to provide long-day treatments. Least accumulated energy occurred in plants grown under naturally short winter days. Orchardgrass generally grew faster than timothy and energy also accumulated faster in it.

Formation of Stem Sites on Creeping-Rooted Alfalfa as Affected by Temperature, Photoperiod, and Gibberellic Acid

Creeping-rooted alfalfa has received genetic, anatomic and morphologic attention but physiologic work has been limited. The primary objective in this study was to measure effects of temperature and daylength and also gibberellic acid on initiation of stems on roots of several clones of creeping-rooted alfalfa. Two daily temperature means, 60° and 70° F, were used in combination with two daylengths, 9 hours and 15 hours, and with and without aqueous solutions of gibberellic acid.

The number of sites developed on plants under short days was consistently greater than under long days and also varied with the clone. Dry weights of top growth of all clones as well as lengths of internodes and lateral branches were less under short daylengths. Root weights, branching, and reserves (total available carbohydrates) were relatively insensitive to daylength. The increased site formation under short days could not be directly related to any of the morphological or physiological responses measured.

Gibberellic acid reversed the short-day growth habit of tops and also site formation. This and indirect evidence obtained from the relative rates of top growth suggest that site formation may be affected by an unknown growth-regulating substance produced in the tops.

Phosphorus Fertilization of Grasses and Legumes

Response to phosphorus when other elements are not limiting--Timothy, tall fescue, and ladino clover responded alike to P concentrations in nutrient solution added to perlite cultures. The differential response of these same species in previous experiments was probably a result of a soil toxicity which was corrected by phosphorus fertilization. The available evidence indicates that this hypothetical soil toxicity did not involve iron, manganese, or aluminum.

Perlite is not recommended as a growth medium for such studies because of its rigid structure when wet, and its relatively low moisture holding capacity compared to soil and expanded vermiculite. Tall fescue grew better on perlite than did either ladino clover or timothy thus demonstrating a differential response of species to growth medium.

Experiments conducted in solution culture to determine the effect of withdrawing P at different growth stages on the subsequent growth of ladino clover revealed the following:

Phosphorus withdrawal and growth curve of ladino clover seedlings--Phosphorus withdrawal resulted in decreased leaf area followed by decreased top weight with root weight affected least and last. Relative leaf growth rate (area) was decreased by P withdrawal more than relative growth rate. Top weight/leaf area ratios were consistently higher in plants after P was withdrawn from the nutrient solution. Net assimilation rates (mg/cm²/day) increased following withdrawal of P from the solution, followed by a decrease when P deficiency became acute. Leaf area growth was decreased by P withdrawal while net

assimilation rates increased, thereby indicating that P requirements for photosynthesis were less than those for leaf area growth. Phosphorus withdrawal increased the proportion of total plant weight in roots, and in petioles. Stolon production was also decreased by P withdrawal.

The relative yield reduction compared to that of controls receiving adequate, or supra-optimal P was always greatest at early growth stages. The extent of the yield reduction appeared to be a function primarily of the plant's growth rate, and level of P accumulation prior to withdrawal. Phosphorus accumulations of 1.3% and 0.97% were found in roots of ladino clover grown in the winter and spring experiments, respectively. Leaves associated with stolons accumulated more P than did leaves associated with the parent plant. Immature leaves accumulated higher levels of P than older leaves.

Mineral nutrient distribution in ladino clover--An increasing gradient of P content always existed from older to younger plant leaves. This increasing gradient from old to young leaves also existed for zinc. Older, mature leaves contained more K, Ca, Mg, Mn, Fe, B than young immature leaves. Copper and aluminum contents were relatively constant in leaves of different physiologic age. Leaves contained more N, Ca, B than roots. Roots contained more Fe, Zn, Cu, Al, Sr than leaves. The Mg and Mn contents did not vary greatly between leaves and roots. Phosphorus withdrawal from the nutrient solution did not reduce K, Ca, Mg, Mn, Fe, Zn, Cu, Al contents but did reduce N and P contents.

RESEARCH AT BELTSVILLE, MARYLAND

Title: FUNGICIDES WITH AND WITHOUT LATEX COMPARED FOR TURF DISEASE CONTROL

Leaders: K. W. Kreitlow and F. V. Juska

Eight fungicides with and without latex emulsion were evaluated at Beltsville, Maryland for control of foliar diseases on a Kentucky bluegrass turf maintained at two nitrogen levels. With the exception of Dithane S-31 and PMA, lower average disease scores for Helminthosporium leaf spots resulted when latex was added to fungicides. There was no interaction between the two N rates on incidence of disease in plots treated with fungicides plus latex. For fungicides without latex, best disease control resulted in plots at low N level. Of the fungicides to which latex was added, PMA, Dyrene, Actidone-thiram, and Tersan OM gave best disease control. When latex was not added to fungicides, PMA, Dithane S-31, Dyrene and Tersan OM gave best control. There was no evidence that addition of latex to fungicides improved control of dollar spot disease. Tersan OM with and without latex gave comparable control of brown patch disease in 11 bentgrass varieties and strains. Latex alone had no apparent fungicidal activity.

Title: FUNGI CAUSING ROOT AND CROWN ROTS OF BIRDSFOOT TREFOIL IDENTIFIED

Leader: S. A. Ostazeski

Root and crown rots are among the most destructive diseases of birdsfoot trefoil. Studies at Beltsville, Maryland suggest that at least 3 distinct types occur in different areas. A type in which Fusarium spp. predominate is found in cooler regions comprising New York, western Virginia, and western North Carolina. A second type involving Leptodiscus terrestris occurs in warmer areas as represented by Maryland and Missouri. A third type caused by Rhizoctonia solani has been found only in Indiana. Of the three, the Leptodiscus crown and root rot seems to be most widespread and destructive. Another, as yet unidentified root pathogen, which resembles L. terrestris and Sclerotium bataticola has been frequently isolated and proved pathogenic on birdsfoot trefoil.

Title: APHID TRANSMISSION OF CLOVER VIRUSES BEING EVALUATED

Leaders: K. W. Kreitlow and R. S. Van Denburgh

At Beltsville, Maryland, studies on aphid transmission of viruses in white clover are being conducted cooperatively with the Entomology Research Division. A strain of pea aphid is being maintained on healthy and virus-infected plants

of the same clonal line of ladino clover. Diseased clover plants contain a mixture of alfalfa and white clover mosaic viruses. Different techniques for feeding aphids on individual trifoliolate and single clover leaflets are being evaluated to determine efficiency of transmission.

Title: WHITE CLOVER SEED SOURCES EVALUATED FOR LOW TEMPERATURE TOLERANCE

Leader: R. A. Kilpatrick

At Durham, New Hampshire, 61 seed sources of white clover were tested for tolerance to low temperatures. The survival percentage varied from 0 to 67.4%. Plants selected for resistance and susceptibility to artificial low temperatures were compared to 10 standard selections in the field. Results indicated that the laboratory method for screening for cold tolerance was comparable to field evaluation.

Title: EFFECT OF TARGET SPOT INFECTION COMPARED ON RESISTANT AND SUSCEPTIBLE RED CLOVERS

Leader: R. A. Kilpatrick

Resistance to the target spot fungus Stemphylium sarcinaeforme is being sought among 71 seed sources of red clover at Durham, New Hampshire. Of 22,000 plants examined, none was immune to the disease, but some resistant plants were found. Chemical analysis of diseased and healthy leaves showed that infection increased the amount of ash and crude fiber but decreased protein, ether extract and nitrogen-free extract.

Title: VIRUS INFECTION AFFECTS PERSISTENCE OF LADINO CLOVER

Leader: K. W. Kreitlow

Earlier work at Beltsville, Maryland, showed that virus infection in ladino clover reduced forage yield up to 55% and seed yield up to 53%. When plots of 3 clonal lines of ladino clover were protected from virus infection by insect-proof cages, plants persisted better and yielded up to twice as much forage. Unprotected plots of the 3 clonal lines progressively developed an estimated 50% virus infection over a 2-year period.

Title: INSTABILITY OF BACTERIAL VIRULENCE A PROBLEM IN REFINING ALFALFA
COTYLEDON INOCULATION TECHNIQUES

Leader: K. W. Kreitlow

Research to refine the cotyledon inoculation technique for testing bacterial wilt resistance in alfalfa was continued at Beltsville, Maryland. Preliminary data suggest that comparable infection results when cotyledons of seedlings from 5 days up to 13 days age are inoculated.

Critical evaluation of certain cotyledon inoculation techniques has been hampered by difficulties in maintaining a high and constant level of virulence in cultures of the organism. Cultural methods tried to date include rapid transfer to suitable agar culture media, preservation in frozen roots, preservation in sterile distilled water. None of the techniques tried so far has stemmed decline in virulence, nor has any method tried to date served to restore virulence of cultures.

REPORTS OF R. AND M. COOPERATIVE RESEARCH

Title: PROJECT NE-9 - THE INTRODUCTION, TESTING, MULTIPLICATION, AND PRESERVATION OF POTENTIALLY VALUABLE PLANTS FOR CROP IMPROVEMENT AND INDUSTRIAL USE

Leader: R. G. Creech, Chairman, Regional Technical Committee

Cooperators: Conn. (Storrs and New Haven), Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Cornell and Geneva), N.C.R.B., C.S.E.S.S., S.C.S., Eastern Util. Res. and Dev. Div., R.P.I.S., ARS, USDA

Regional Station Program (as related to forage crops)

At Geneva, 953 forage legumes and grasses were in the 1963 plantings. Among the forage introductions are 300 forage legumes and grasses carried over from 1962. All introductions successfully seed increased in 1963 are being catalogued and seed will be available to plant breeders. Descriptive and evaluation notes will be added to the catalogue. A summary of performance information concerning introductions at 14 Experiment Stations is also attached as a supplement.

Screening at the University of New Hampshire revealed a low incidence of Stemphylium sarcinaeforme in 8 red clover introductions of which 4 had been selected at Geneva. White clover, also screened at New Hampshire, had 2

introductions with 62-67% winter survival, compared with 48-50% for the standard varieties, Pilgrim, Certified Pilgrim and Oregon. One of these 2 introductions had also been selected from original introductions at Geneva.

A new variety of timothy especially adapted for pasture use may be derived from 2 introductions, P.I. 234444 from Belgium and P.I. 237191 from the Netherlands. Their main features are low, stooled-out habit; leafy, short culm; vegetative and rapid regrowth; late bloom, possibly 2 1/2 or 3 weeks later than common timothies; winter hardiness proved as far north as Ottawa, Ontario; possible rust tolerance. The same timothies have been found promising by SCS for use in stabilizing waterways and water outlets. They are poor seed producers, but at several locations efforts are being devoted to selection of seeding plants.

Title: PROJECT NE-13 - STUDIES OF THE PHYSICAL PROPERTIES, BEHAVIOR, AND FORMS OF FORAGE AS RELATED TO ENGINEERING APPLICATION

Leader: G. L. Byers, Chairman, Regional Technical Committee

Cooperators: The twelve Northeastern Agricultural Experiment Stations and A.E.R.D.-ARS, and C.S.E.S.S. (USDA)

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

Experiments were conducted on the resistance to bending at a displacement of 0.025 inches for three varieties of alfalfa: DuPuits, Vernal and Narragansett. No large differences were found between varieties at each of four moisture levels. However, the resistance to bending increased with decreasing moisture content and more rapidly at the lower moisture levels. Stem diameter decreased lineally with moisture content. Compressive tests showed no apparent difference between varieties. However, the ultimate compressive force increased with decreasing moisture content and decreasing specimen length.

A new clutch and fly wheel assembly plus allied power and controls were added to the mechanical hay wafering press. A recorder wafer expansion evaluator was constructed. A system of controlling wafer forming pressures was constructed and found to be successful within limits.

Experience with the wafer system for handling forage has shown that it has little usefulness in the humid regions of the United States until some methods are found to overcome the restrictive moisture content conditions now applicable to successful wafer production.

Analyses and publications of the first four years of study of physical properties and storage requirements of haylage has been completed; involving data on permeabilities of silo wall sections, friction coefficients of haylage on various wall surfaces and shear strength of stored haylage in the vertical shear plane.

Several improvements were added to the impact type corn chopper. Capacities of one-half tons per hour of green material per horsepower input were consistently obtained.

Drying isotherms were developed for baled hay positioned flat and on edge. Partial correlations of bale density, moisture content, and spontaneous heating effects on the isotherms have been completed. Biological causes of spontaneous heating are being investigated.

Thin layer drying rates of forage crops have been analyzed according to the falling rate theory of drying. A drying rate chamber permitting measurement of plant temperature during drying under controlled air temperature, air flow and intensity of infrared radiation has been constructed.

Stomata response of alfalfa leaves was investigated by two methods; (1) silicon impression-peel method, and (2) reflected light technique. Examination of photographs of stomata made possible through the use of these techniques indicates the possibility of accelerating the drying rate of leaves by controlling stomata opening.

Three similar bales of alfalfa hay were dried simultaneously with heated air at temperature levels of 90°, 120°, and 150°F and equal sensible heat input. The data obtained will be analyzed to establish the correlation between rate of moisture loss and the vapor pressure differential for each drying temperature.

Experimental data have been accumulated to substantiate the theory and thus the usefulness of analytical description of forage flow through the impeller blower and related system.

Tentative relationships for pressure drop in fifty feet of pipe and the air velocity within the pipe for different rates of material conveyed have been determined for 9 1/4 and 14 inch diameter pipes.

USEFULNESS OF FINDINGS:

Knowledge of the physical properties of forages aids investigators as well as designers of harvesting and processing machines. Sidewall friction data provide for understanding the behavior of haylage with respect to settling pattern, storage capacity, preservation, and removal. Data on shear strength provide information relevant to rational equipment design.

The rate of decrease of stem diameter with corresponding decreases in moisture content may be of value to investigators working with hay drying systems.

An understanding of the phenomena of how moisture moves in a drying plant and is eventually released will be a contributing factor to the development of methods for increasing forage drying rates.

Vacuum drying for forage appears to be impractical as an economic process with today's sources of available energy and known technology.

A more thorough understanding and measurement of processes in hay drying and development of mathematical relationships which will explain and predict hay drying should result in improved hay drying practices.

Work with a chopper indicates that a high speed turbine-type machine has possibilities.

The relationship among pressure drop for a given pipe size, specific rate of material flow, and the minimum air velocity required for conveying chopped hay forage will facilitate design of pneumatic systems.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEEDS THROUGH IMPROVED TESTING PROCEDURES

Leader: Frederick E. Hutchinson, Chairman, Regional Technical Committee

Cooperators: Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Geneva and Ithaca), Pennsylvania, and Rhode Island Agricultural Experiment Stations, F.C.R.B., ARS, USDA - C. S. Garrison, V.O.R.B., S.E.S.D., ARS, USDA, and B.S.B., A.M.S., USDA

A revised project outline was adopted to emphasize principles of testing rather than testing individual crops, including a clear statement to show that the project is not involved in the area of breeding and variety development.

In New York, work was done with timothy, ryegrass, birdsfoot trefoil, red clover, and alfalfa. Three varieties of timothy and one unknown sample were grown in the greenhouse from both vernalized and unvernallized seed. The plants were transferred to the field in early May and all bloomed in July. The three varieties could be differentiated by time of bloom, length of head, and resistance to rust. Captan and Cycocel treatments produced differential varietal reaction in the greenhouse. Birdsfoot trefoil varieties could be separated by their reactions to photoperiod, light intensity and temperature in growth chambers. Conditions have been worked out that induce a high percentage of red clover, alfalfa, and birdsfoot trefoil plants as well as timothy and ryegrass to bloom within 5 weeks of the time of planting the seeds. Some off-types can be identified, as for instance a high percentage but probably not all contaminants of European plants in Viking trefoil could be detected by differential reaction to environmental conditions.

In New York, also, 8 different types of seed germination chambers were studied for precision in maintaining desired temperatures. The information may be obtained on request to the Geneva Station.

In Pennsylvania various paper chromatographic techniques were applied in studies of varietal identification of several grass and legume species. The method appears promising in the identification of constituents such as phospholipids, free amino acids, and leaf phenols which differ among species.

Colorimetric and spectrophotometric techniques in differentiating flower color differences of 12 to 15 varieties of alfalfa may be of use in testing varietal purity. Plans are also under way to explore serological tests in varietal purity testing.

At Beltsville, Maryland some efforts are being applied to develop vigor tests using respiration studies.

A study is being made of fungi that cause deterioration of seed in storage. Sixteen different temperature and humidity conditions were used and gamma rays were applied to determine their effectiveness in killing or inactivating storage fungi on seeds of 8 species. Storage mold of bluegrass seed may be reduced when an 80,000 rad dosage is used.

At the Seed Branch, AMS, USDA, bioassay work is being done to evaluate the adequacy of seed treatments. Varietal purity tests are being made on 47 varieties of alfalfa involving 225 samples. Sorghum varieties are being tested in the field and growth chambers. Smut tests and reaction to herbicides and insecticides were made in the field. Varieties can be differentiated by their response to continuous light, and also by coleoptile color. The Roskilde variety of ryegrass could be distinguished by its development of lateral roots within 15 days. IBM cards are used for recording field data.

Title: PROJECT NE-24 - NUTRITIVE EVALUATION OF FORAGES

Leader: J. W. Bratzler, Chairman Regional Technical Committee

Cooperators: The 12 Northeastern States and The U. S. Regional Pasture Research Laboratory, D.C.R.B., ARS, and CSRS

Daily rate of consumption of forages, as an additional measurement of their nutritive value, received considerable attention this past year in order to obtain a more accurate assessment of the influence of several factors upon the nutritive value of forages. Factors studied were: (1) nitrogen fertilization (Delaware, New Hampshire, Pennsylvania, Rhode Island, and West Virginia,) (2) fertilization with minerals (Maine and West Virginia, (3) cutting date and growth stage (Delaware, Maine, Maryland, New Hampshire, New York, Pennsylvania, Rhode Island, Vermont, and Dairy Cattle Research Branch, ARS), (4) forage varieties within a species (Delaware, Maryland, New Hampshire, and New York), and (5) physical form of the forage as fed (New York), (6) effect of heat drying (New Jersey), and (7) differential harvesting (Maine, Maryland, and Vermont).

Considerable effort was also expended during the year in the study of: (1) metabolism of forage nitrogen (Delaware), (2) complete balances of energy (Maine, New Hampshire, New Jersey, and New York), (3) rumen fermentation patterns as affected by level of forage intake (Massachusetts), (4) patterns of forage preference (West Virginia), (5) relation between the ease of hydrolysis of the hemicelluloses and digestibility of forages (U. S. Regional Pasture Laboratory), (6) correlation of in vitro cellulose fermentation with level of nitrogen fertilization employed in the production of experimental forages (Delaware), (7) new and refined procedures for predicting nutritive value of forages from the cell wall constituents, acid-detergent fiber, and lignin (U. S. Regional Pasture Laboratory and Dairy Cattle Research Branch, ARS), and (8) conventional versus cafeteria system for the determination of consumption of forages (West Virginia).

Data obtained from the contributing projects again emphasize the importance of the date of harvest of forages upon their nutritive value. Dry matter digestibility of Potomac orchardgrass declined from 80% on April 25 to 50% on June 4 (Maryland). With two varieties of timothy, crude protein content decreased about .35 percentage units for each day's delay in harvest after June 1 (New Hampshire). For these same forages, decreases in digestible, metabolizable, and net energy values were of comparable magnitude. Dry matter digestibility of Ranger alfalfa declined from 67% on May 23 to 55% on July 3 (Dairy Cattle Research Branch, ARS). Declines in digestible protein and energy were similar.

Considerable attention was given during the past year to a study of the factors which influence the rate of consumption of forages. Consumption of orchardgrass increased with the level of nitrogen fertilization, up to 200 lb/a. (Delaware). Dry matter intakes did not follow the changes in digestibility of Potomac orchardgrass which occurred during the early stages of maturity and S-37 orchardgrass, harvested on the same dates, gave consistently higher rates of consumption (Maryland). Daily consumption of pelleted, finely ground forage was distinctly greater than that of the same forage fed in chopped form (New York). The differences were more marked with late-cut forages than with early-cut forages. Consumption of early-cut forages, regardless of form, was definitely superior to that for late-cut forages. Allowance of 10% refusal of the forage offered in the determination of consumption rates indicates that the composition of the forage offered differs but little from that of the forage actually consumed (Pennsylvania). Fertilizer treatments (N, P, and K) upon Kentucky 31 fescue had little effect on consumption of aftermath cuttings in regular feeding trials (West Virginia). Under the free-choice regime, consumption of the first cutting hays was significantly higher.

A further study of the effect of drying temperature upon the digestibility of alfalfa hay showed that a temperature of 125°F was superior to the 200°F and 275°F temperatures (New Jersey). Field-cured hay was equivalent in the nutrients studied to the hay dried at 200°F and superior to that dried at 275°F.

Progress was made in the development of new as well as more refined chemical methods for the nutritive evaluation of forages. Improvement has been reported in the method for the quantitative determination of the hemicellulose which measures the total nonfermentable sugars released upon the hydrolysis of hemicelluloses (U. S. Regional Pasture Laboratory). New techniques have been developed to study the nutritional chemistry of forages which include an acetone-dried powder method of preparing rumen contents for lignin analysis without the application of heat; a method of weighing samples, before cooling, which increases both the precision and speed in the handling of acid-detergent fiber and lignin analyses; and a new procedure using detergents for the preparation of cell wall constituents of forages (Dairy Cattle Research Branch, ARS). Studies relating to the theory by which lignin affects digestibility have led to the mathematical development of an index of digestibility or availability of forage nutrients which is calculated from the cell wall constituents, acid-detergent fiber, and lignin.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST

Leader: V. Ulrich, Chairman Regional Technical Committee

Cooperators: Connecticut (Storrs), Maryland, New Hampshire, New York (Cornell), Pennsylvania, Rhode Island and West Virginia Agricultural Experiment Stations; U. S. Regional Pasture Research Laboratory, F.C.R.B. and S.E.S.D., ARS, USDA, and A.S.T.A.

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

Breeding and evaluation for four forage species were conducted in programs in seven Northeastern states and the U. S. Regional Pasture Laboratory. Seed production of experimental materials for strain synthesis investigations and regional evaluation studies were continued in three states.

Regional Evaluation of New Synthetic Varieties of Forage Crops

Third year data for performance of experimental varieties under severe and moderate harvest managements were obtained from trials in these locations:

Alfalfa - Conn., West Va., Maryland, Pennsylvania, and New York (3)
 Bromegrass - West Va., Maryland, Pennsylvania, New York, and
 New Hampshire
 Orchardgrass - West Va., Maryland, Pennsylvania, New York

With a few exceptions, 1963 concludes evaluation on these 1960 trial series. They have provided comprehensive information on both variety and species performance over the region. Severe management treatments were effected by removal of the first harvest about one week earlier than the moderate treatment at all Stations and with a regrowth interval shortened by one week between the first and second harvests. This reduced yields appreciably on all

species compared to the moderate treatment and resulted in premature stand losses on alfalfa and brome grass. The effect was least severe at the most southern site in Maryland. It can be generally concluded that response to management for these species over the region is sufficiently defined that differential managements are not necessary to ascertain the maximum expression of genetic differences in advanced evaluation trials.

Cooperative Forage Breeding Studies

Orchardgrass---Data were obtained at New York on three polycross progeny trials that evaluate 66 parental clones of early, medium and late classification. This series was planted in 1962 at N. Y., Pa. and West Va. Establishment was not successful at the last two sites but the series was replanted in 1963 in Pennsylvania.

Brome grass---Polycross progeny trials established in 1961 and 1962 are under evaluation at both Pennsylvania and New York. Data were obtained in 1963.

At the U. S. Regional Pasture Research Laboratory, greenhouse studies are in progress with polycross progenies of 18 brome clones selected for resistance to Helminthosporium bromi and with some resistance to Stagonospora bromi. These were inoculated as seedlings with Helminthosporium bromi. The percentages of plants rated as 1 or 2 on a scale with 5 being most susceptible exceeded 90 for 6 polycross progenies and ranged from 80 to 90 for 7.

'Saratoga' and 'Manchar' had 6% and 0% resistant plants, respectively. Later in the winter the regrowth was inoculated with Stagonospora bromi. Four polycross progenies with at least 90% plants resistant to Helminthosporium were scored better than 2.0 on a similar scale regarding resistance to Stagonospora bromi. Saratoga and Manchar scored 3.5 and 2.7, respectively.

Two plantings of these polycross progenies were established at University Park, Pa., to study reaction to field infestation and forage quality. One planting of selected clones was established in cooperation with Gerald M. Dunn at Durham, N. H. to study resistance to scald.

Variety Synthesis Studies for Perennial Forages

Investigations on synthesis procedures are in progress for five species: alfalfa, birdsfoot trefoil, timothy, brome grass, and orchardgrass. Much of the current work except for alfalfa is in the production of seed of appropriate experimental materials for these studies. Most of this production is under isolation cage at three locations: New York, Pennsylvania, and New Hampshire. A limited amount of contract production in California is also continuing. Seed production in 1963 was generally successful. The scope of this activity is briefly reported below:

New York Isolation cages for:

B. F. Trefoil	-	<u>24</u> cages (12' x 12'); <u>3</u> cages (12' x 24')
Alfalfa	-	<u>18</u> cages (10' x 20'); <u>10</u> cages (12' x 24')
Timothy	-	<u>35</u> cages (8' x 16')
Brome grass	-	<u>12</u> cages (4' x 4')

Plantings were made in 1963 for additional production in 1964 for 41 cages of birdsfoot trefoil, 24 cages of timothy, and 12 cages of alfalfa. Winter survival is doubtful on the alfalfa, owing to dry weather.

Contracts were made for 4 cage increases of creeping-rooted alfalfa synthetics in California during 1963. These were successful.

Pennsylvania

Isolation cages for orchardgrass -

8 cages (10' x 20'); 6 cages (4' x 4')

Field isolations - Syn₁ and Syn₂ generation seed for 11 synthetics constituted on regional performance.

New Hampshire

Field isolation - Syn₂ generation seed of 12 single crosses.

Field and greenhouse crosses - 285 for development of mutant marker stocks.

In the evaluation phase of the synthesis studies, data were obtained from alfalfa synthesis trials I and II at New York. Alfalfa synthesis trials III, IV, V, and VI were established at 2 locations each in New York and at 1 location each in Pennsylvania.

Synthesis studies involving the effects of cage environment are in progress at New York through the use of birdsfoot trefoil stocks with a dominant HCN reaction marker. This character can be identified in month-old seedlings and is a very useful tool to study synthesis procedures. Crossing under cage in single crosses and synthetics was shown to be markedly reduced for clones with a high index for self fertility. Amount of crossing was definitely affected by plant position within the isolation cage. Alternate planting of clones for crossing gave a greater percentage of crossed progeny than alternate row planting. Bee visitation observations showed a greater tendency for within-row rather than between-row visits. These studies are being continued.

At New Hampshire and New York, efforts are being made to obtain mutant stocks of bromegrass that might be used in a similar manner for this perennial grass species. In a pollen dispersal test with chlorophyll mutants in 1963, no significant contamination occurred at 50 - 750 feet from a single dominant green clone having a total of 119 heads. In another test, significant contamination did occur at 450 feet (the maximum distance available) when the pollen source consisted of about 1/2 acre of green plants. A considerable amount of selfing, sibbing, and crossing was done in 1963 with chlorophyll and other mutants in bromegrass.

USEFULNESS OF FINDINGS:

Polycross progeny and synthetic trials are an invaluable source of information concerning the geoclimatic-genotypic interaction on forage quality, productivity, disease resistance, management tolerance and stand longevity.

This knowledge is essential for isolation of superior forage populations that are to be released in the Northeastern region after some twenty odd years of breeding research. These superior forage materials provide a very important part of the northeastern plant agricultural base.

Specific contributions of current studies are: (1) information critical to release of five alfalfa varieties. Two of these, Saranac and Cayuga, have been released; two others are still under consideration. (2) information critical to the release in 1963 of the high yielding and persistent orchard-grass variety of medium maturity, Pennmead.

The seed production and variety synthesis investigations are of great value because they test breeding methodology theory; find new means of making maximum use of heterosis in forage plants; create new methods of forage improvement whereby the time required, from the initiation of an improvement program to variety release is shortened significantly. Furthermore, through improvement in seed production techniques, the cost and efficiency of seed production as well as consequent marketing, distribution and pricing of seed are facilitated at both the producer and consumer ends.

WORK PLANNED FOR NEXT YEAR:

All trial series established in 1961, 1962, and 1963 for regional synthetic evaluation, polycross progeny testing and variety synthesis investigations will be continued. A few 1960 series trials will be continued but most will be concluded with the summarization of 1961-63 results.

New plantings will include alfalfa trials in eight states and synthesis studies on timothy in two states.

Seed production of experimental materials for use in planned future studies will continue.

Title: PROJECT NE-29 - MANAGEMENT AND PRODUCTIVITY OF PERENNIAL GRASSES

Leader: Madison Wright, Chairman Regional Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations, Forage and Range Research Branch, Regional Pasture Research Laboratory, and C.S.E.S.S., ARS, USDA

Nineteen sixty-three was devoted to transition from work under the regional project, "Management and Productivity of Perennial Grasses" to the new one, "Morphological and Physiological Responses of Perennial Forage Grasses."

In Maine, Maryland, New York, Rhode Island, and Vermont uniform final harvests at bloom followed a uniform light application of nitrogen early in the spring. At the West Virginia station, timothy was likewise uniformly handled, but

Potomac orchardgrass was variously managed another year. In Pennsylvania all four entries were continued under various managements. The differential managements were prolonged because the 1962 dry weather minimized treatment effects.

Spring stand ratings of Climax timothy at stations that carried out uniform harvesting showed little influence of previous treatment in Maine, but a first cutting at an early stage was decidedly adverse to stand maintenance in Rhode Island and West Virginia. In Pennsylvania, however, there was greater basal area in plots cut at early stages. Thinner stands of timothy followed heavy nitrogen fertilization. Effects of cutting height on stand were negligible. Yields from plots handled uniformly in 1963 were influenced by the differences in stand previously described, but the high nitrogen plots in Rhode Island showed a yield advantage and essentially equal yields at West Virginia despite poorer stands. Residual effects of stage of first harvest on yield were marked, except in Maine, and the combination of high nitrogen and early harvest was especially detrimental in West Virginia.

Stands of Saratoga smooth brome were adversely affected by early harvests and heavier application of nitrogen. Yields from the uniform harvests were markedly influenced by previous schedules in Maine, Rhode Island, and Vermont, but not in Maryland or New York. Residual effects on yield of heavy nitrogen fertilization were favorable in Maryland, Rhode Island, and Vermont, but not in New York, where stands were thin in all plots. Ample rain the previous fall may have minimized carry over. Height of cut influenced yield only in Vermont. Lincoln behaved much like Saratoga in the only terminal comparison made in New York, but showed even smaller residual differences.

Reed canarygrass stands were thicker in 1963 in plots previously harvested at advanced stages of maturity but yields were not significantly influenced in the 2 terminated trials (Maryland and New York). In Maryland, high nitrogen rate was associated with superior stand and yield, but previous high cutting though followed by a better stand, was associated with lower yield. In Pennsylvania, better stands were found on plots previously given the lower rate of nitrogen.

Potomac orchardgrass was 90% winterkilled in Rhode Island and dropped from the experiment. In Maryland most of the plots had 90% ground cover in the spring of 1963 and previous heavy fertilization was beneficial to yield. In New York, where all plots had been weed-free and highly productive in 1960-62, stands were thin and/or weedy in 1963 and previous heavy dressings of nitrogen were interpreted as unfavorable to stand and yield. Neither Maryland nor New York reported residual effects on yield of timing of the first harvest, but plots previously cut low were more productive in Maryland. Closely clipped plots had thicker stands in Pennsylvania, but poorer stands in West Virginia, where late cutting and higher level of nitrogen were likewise unfavorable. Pennlate responded similarly to Potomac but showed certain less marked residual effects.

A member of the technical committee has agreed to collate and interpret the data for each of the four species (timothy, brome, orchardgrass and reed canarygrass), and to develop a manuscript for an experiment station research bulletin. In this effort each "species leader" is being assisted

by the members who included that species in their contributing projects, while a general chairman is acting to coordinate the four publications and will take the leadership also in preparing a journal article derived from them. A common format has been developed for use by individual stations in summarizing their data, and another has been proposed for the four parallel publications. The statistical processing and interpretation of data collected during 1960-63 are well advanced.

During 1963 progress was made toward the several objectives specified in the revised outline, as follows:

Objective 1: To study the effects of environment on morphology and growth rate

Application of increments of nitrogen fertilizer produced an increase in the growth of roots, and the number of regrowth tillers of timothy. Corms that were formed were generally smaller (Rhode Island). Increased nitrogen fertilization also raised the content of nitrate (New York) and digestible energy (Connecticut) in reed canarygrass. In the latter experiment fall regrowth potential was not affected by varying the rate of nitrogen fertilization although rhizome weights increased with rate. Varying the timing of nitrogen applications influenced total and aftermath growth of timothy strongly in the greenhouse but not in the field (Rhode Island). Daily maximum and minimum air temperatures were not significantly associated with rate of elevation of the growing point in reed canarygrass or Climax timothy (Pennsylvania). Attempts to promote floral induction of reed canarygrass by vernalization in a growth chamber were unsuccessful (New York).

Objective 2: To study the effects of defoliation on morphology and growth rate

Removal of upper or lower leaf blades from shoots of reed canarygrass confirmed previous findings that rate of leaf formation is independent of the severity of this treatment. Removal of leaf blades from a shoot did not affect the rate of development of its tiller, and vice versa (New York). Rhizomes of reed canarygrass weighed least in the fall where the first harvest of the year had been made at early head (Connecticut). In timothy more and heavier tillers developed where the first cut was taken at early head rather than later, but a greater number of corms formed where the first cut was delayed (Rhode Island).

Objective 3: To study factors influencing food reserves

Detailed studies of reed canarygrass rhizomes were undertaken following the development of a satisfactory analytical procedure and recognition of fructose and its polymers as the carbohydrates most indicative of reserve status (Connecticut). There was an increase in fructose from spring activation until early jointing and rhizome elongation, followed by a decline to the mid-boot stage. A depletion phase of about 14 days duration followed each defoliation. Maximum levels of fructose were confined to the time of fall dormancy (Connecticut). Three to four days after the application of nitrogen fertilizer on orchardgrass early in the spring, carbohydrate

reserves in the plant dropped sharply. The magnitude of the drop varied directly with the rate of application (Massachusetts). Old rhizomes contributed importantly to the development of buds on adjacent young rhizomes or stem bases in reed canarygrass (New York).

Objective 4: To establish the nutritional value of forage samples representative of specific management systems

The artificial rumen was used to estimate coefficients of digestibility of energy, dry matter, and protein in 105 samples harvested from the NE-29 management plots in several states in 1962. For energy the coefficients ranged from 44 to 83 and for dry matter from 48 to 86. Percent digestible protein ranged from 3 to 28 (West Virginia). Percent digestible energy of reed canarygrass harvested in 1963 declined especially rapidly between mid-boot and early head, and during that interval and thereafter the decline was rapid enough to offset gains in dry matter (Conn.).

Nutritional evaluation work is being carried forward in cooperation with representatives of NE-24 at several stations (Maine, Maryland, Massachusetts, New Jersey, Vermont). In three cases (Maine, Maryland, Vermont) the forage is being harvested at stages identical with those specified in the recent grass management experiments. Both in vivo and in vitro techniques are in use, along with chemical determinations. In the Maryland tests, Potomac orchardgrass was compared with the later-maturing S-37. The digestibility and intake of both remained rather high until early head but dropped rapidly following flowering. Harvesting the two varieties simultaneously produced forage substantially different in stage of maturity and in quality.

USEFULNESS OF FINDINGS:

The grass management studies conducted in 1959-63 are in the aggregate the most comprehensive ever conducted in this country. They provide a guide to expected levels of yield and persistence for the principal perennial grasses of the region, under a range of fertilization and cutting managements wide enough to span almost any intensive schedule contemplated by farmers. These experiments have demonstrated that stands and yields of certain species are profoundly influenced by timing of harvest and use of nitrogen fertilizer, while others are seemingly less sensitive. Differences in suitability of certain species from place to place within the region have also been demonstrated. As nutritional evaluation of forage produced under representative management schedules proceeds, it will be possible to express yields in terms more meaningful to those concerned with the nutrition of livestock. Better understanding of the morphology and physiology of these plants should suggest management systems that will make high yields, longevity, and high nutritive value more compatible than they are now.

Title: PROJECT NE-35 (REVISED) - ANALYSIS OF NORTHEASTERN CLIMATIC
VARIABLES AND THEIR RELATIONSHIPS TO PLANT RESPONSE

Leader: A. V. Havens

Cooperators: Connecticut (New Haven and Storrs), Delaware, Maine, Maryland,
Massachusetts, New Hampshire, New Jersey, New York (Ithaca and
Geneva), Pennsylvania, Vermont, and West Virginia Agricultural
Experiment Stations; ARS, CSRS, ARS, USDA, and Weather Bureau,
USDC

Several regional publications have been completed.

In Delaware monthly records were analyzed to determine a monthly drought
index. The climatological divisions of the Northeast are now being analyzed
by the Palmer method for 1930-1963.

At the West Virginia Station extreme rainfall has been studied. Twelve
stations from the Northeast have supplied data for the study of frequency dis-
tributions. A fairly distinct seasonal influence appears for the storm
events and stations analyzed. The value of weather patterns has not been
assessed as yet.

In weather record processing daily punched-cards are being transferred to
magnetic tape for use in more rapid data processing on some of the newer,
larger, and faster computers.

Title: PROJECT NE-43 - PROFITABILITY OF ALTERNATIVE FORAGE SYSTEMS FOR
NORTHEAST DAIRY FARMS AND NE-43R: PROFITABILITY
OF ALTERNATIVE FEED HANDLING METHODS ON NORTHEAST
DAIRY FARMS

Leader: J. P. Marshall, Chairman Regional Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations; C.S.E.S.S.,
ARS, USDA; and F.E.D., E.R.S., USDA

A regional bulletin demonstrated that the cropland resources can profitably
be used more intensively on most dairy farms than is now the case. Repre-
sentative case farms selected by the cooperating states demonstrated feasible
changes and profit potential. Another study provided estimates on production,
harvesting, and storage costs of corn silage under alternative storing
techniques.

Title: PROJECT NE-45 - ROOT AND CROWN DISEASES OF ALFALFA AND CLOVERS

Leader: H. W. Crittenden, Chairman Regional Technical Committee

Cooperators: Delaware, New Jersey, New Hampshire, New York, Pennsylvania, Rhode Island, and West Virginia Experiment Stations; The Pasture Research Laboratory and F.R.R.B., ARS, USDA

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Causes of Root and Crown Diseases of Alfalfa and Clovers

Plants were collected in West Virginia in a field of four-year-old DuPuits alfalfa at monthly intervals to find if a change could be detected in the organisms present at different seasons of the year. Two types of plants were collected, those appearing in good condition and those in poor condition. No difference was noted in the organisms obtained from these two groups. Fusarium oxysporum was isolated most frequently, closely followed by F. solani, F. moniliforme and Leptodiscus terrestris in about equal numbers throughout the year. The pathogenicity of several fungi, mainly Fusarium species, isolated from red clover or alfalfa was tested on both red clover and alfalfa seedlings. In seedling tests, some isolates from red clover are more pathogenic on red clover and others are more pathogenic on alfalfa. The same is true of isolates from alfalfa. Some isolates are equally pathogenic on alfalfa and red clover.

In New York during 1963, as in the 2 previous years, Fusarium oxysporum, F. solani, and F. roseum accounted for over 50 percent of the fungi isolated from roots of Cayuga alfalfa established in 1961. F. oxysporum was the species most commonly isolated, and Fusarium sp. comprised the majority of the fungus isolates regardless of whether they were obtained from the epidermis and outer cortex, from the inner cortex and stele, or from the fibrous roots. Pathogenicity tests with isolates representing several genera of fungi indicate that Fusaria, under the conditions employed, are more pathogenic to roots of alfalfa seedlings than are species of Penicillium, Trichoderma, Aspergillus, Alternaria, Mucor and Rhizopus; however, certain of the latter genera cause seed rot. Initial data indicate that, independent of pH effect, the level of calcium available to alfalfa seedlings may influence markedly the susceptibility of seedling roots to attack by Fusarium spp.

Regular periodic isolations of fungi in Rhode Island from infected roots of alfalfa growing in plots of known history have failed to have significance other than a predominance of Fusaria. Controlled inoculation with fusarial isolates has failed to cause consistent reproducible pathogenicity in Rhode Island.

At the Pasture Laboratory in Pennsylvania an isolate of Fusarium oxysporum var. medicaginis was recovered from alfalfa. With inoculations using artificially infested soil, severe symptoms developed within 3 months.

Isolations in New Jersey were continued from the previous year in red clover plots from the root, root surface, and surrounding soil. There was no appreciable difference in the kinds of fungi isolated from 1- and 2-year-old plants. Fusarium oxysporum, Leptodiscus terrestris, F. solani and Pythium sp. (listed in descending order) were commonly isolated. F. oxysporum, F. roseum and Pythium sp. were the principal fungi isolated from the root surface. Fungi found to be most prevalent in soil at the 1-6 and 6-12 inch levels were F. oxysporum, F. roseum, Trichoderma sp., Zygorhynchus sp., Penicillium sp., Mortierella sp., Aspergillus sp., L. terrestris, Rhizoctonia sp. and Pythium sp. Quantitatively and qualitatively fewer fungi were found at the 6-12 inch level than the 1-6 inch level. However, the number of F. oxysporum and F. roseum colonies remained substantially the same at both levels in the two-year-old clover plots. Of the Fusarium isolates, F. oxysporum was prevalent in the soil, on the root surface, and in the root; F. roseum was prevalent on the root and surrounding soil; and F. solani occurred to a lesser degree in all three areas. Leptodiscus sp. and pythium sp. were noteworthy since they were found to be prevalent in the roots.

Tests in Delaware revealed that Rhizoctonia sp. caused severe pre-emergence damping-off of the Pennscott variety in laboratory and greenhouse tests but did not cause appreciable loss of seedlings when 2-week-old plants were inoculated. Fusarium oxysporum caused severe pre- and post-emergence loss of seedlings in both loamy and sandy soils. F. roseum caused some loss of seedlings in pre- and post-emergence tests.

Work has continued at the Pasture Laboratory on determining the cause and factors affecting internal breakdown of tissues in the crowns of red clover. Inheritance studies of the susceptibility and resistance of internal breakdown have indicated that lines with greater resistance can be developed.

Research at the Pasture Laboratory has indicated that insects were a primary factor in stand depletion of red clover. Fungicides used in the experiment had little effect on the persistence of red clover stands.

Various pesticide treatments were used in West Virginia as a means of studying the effect of the materials on certain segments of the soil population that may be related to root rots of red clover and alfalfa. Only slight differences in number or kinds of fungi have been found between different treatments during the first 6 months.

Interactions of the Physical Environment and the Ecological Succession of Parasitic and Non-Parasitic Microorganisms in the Development of Root and Crown Diseases

The numbers and kinds of fungi from the rhizosphere of 4-year-old plants of DuPuits alfalfa were determined in West Virginia during a 6-month period from March to August. Fungi isolated were mainly species of Penicillium, Trichoderma, Mucor, Aspergillus and Rhizoctonia. The species of Fusarium and Leptodiscus terrestris most frequently isolated from the roots were seldom detected in the rhizosphere.

Gliocladium as the antagonist was tested against 6 isolates of Fusarium, 2 of Rhizoctonia and 1 of Leptodiscus in New Jersey. Zones of inhibition developed between the antagonist and test colonies of Fusarium on plates, but the antagonist then continued to grow through the colonies. There were only slight differences between isolate reactions to the antagonist. The test organism, Rhizoctonia, grew rapidly around the antagonist and contained it, showing a mutual antagonism favoring Rhizoctonia. There was also mutual antagonism expressed when Leptodiscus was the test organism. Studies also indicate that Gliocladium is not only antagonistic but also parasitic to Fusarium.

In New Jersey, inoculation with F. oxysporum and Rhizoctonia has shown the Fusarium organism to be effective in penetrating roots of alfalfa plants. Dark brown areas became prevalent on the root surface of inoculated plants from which F. oxysporum was readily isolated. Rhizoctonia apparently was not as efficient a parasite, although it was isolated from brownish areas on the root.

With DuPuits alfalfa as the test plant, 2 greenhouse-staged experiments were conducted in Pennsylvania in which the parasitic capability of varying combinations of Fusarium roseum, F. oxysporum, and F. solani at 3 soil moisture regimes, respectively, field capacity (FC), 1/2 FC, and permanent wilting percentage (PWP), was studied. In both series, isolations were attempted from surface sterilized root tissue and the potting medium. All cases of single fungus species soil infestation resulted in successful root infection. Varying combinations of fungus species as the sources of inoculum, however, resulted in varying degrees of root penetration by the respective species. When F. oxysporum and F. roseum were used concurrently, the order of infection for F. oxysporum was much higher. When F. oxysporum and F. solani were used as mixed inoculum, there were no cases of successful root penetration by F. solani. In all instances, the various fungus species were isolated from the potting medium in the same combinations in which they had been employed at the outset. Soil moisture stress did not appear to influence the level of infection by the 3 species of Fusarium studied.

DuPuits alfalfa and Pennscott red clover were used in Pennsylvania to study the influence of the amino acid and vitamin fractions of root exudates on the parasitic and pathogenic capabilities of soil fungi. Plants of these 2 varieties were grown in steamed soil at varying soil moisture stresses. After 60 days under the assigned stress regime, the soil masses were eluted with 80% ethanol. This extract was concentrated under vacuum, passed through charged resin filters, and is now being prepared for quantitative and qualitative analyses for amino acids and vitamins.

In an effort to show possible interactions between the host and selected fungi, the influence of red clover root exudates on fungi was studied in New Jersey. Exudates were collected from young roots growing under sterile conditions. Dilutions of these exudates significantly reduced the growth rate of F. roseum when added to shake cultures of the fungus.

Studies on pectolytic enzyme production by isolates of several genera when grown on autoclaved alfalfa roots indicate marked differences in the nature of the enzymes produced by different genera. Data were obtained that indicate calcium ions may inhibit, stimulate, or not affect the activity of the enzymes produced by different isolates in New York.

Data were obtained in New York that indicate the Cayuga alfalfa plots that received potash applications (320 lbs/acre) in 1962 had lower root rot ratings, higher stand counts, and plants with markedly higher numbers of buds and fresh weights of roots than did plots that received no potash. Whereas the relative frequency of isolation of Fusarium sp. in 1962 was essentially the same for both treatments, in 1963, Fusarium sp. accounted for a higher proportion of the fungi isolated from roots of plants from the no-potash treatment than from the roots of plants that received potash.

Data obtained in New York have shown that as the frequency of the cutting of DuPuits alfalfa was increased the root rot increased and the number of plants decreased.

The effect of cuttings made at different heights from soil level on the development of root rot of ladino white clover was determined in a greenhouse ground bed and in field plots in New Hampshire. It was found that severity of root rot increased and average dry weight/plant decreased as the height at which cuttings were made was decreased. Growth of plants was greater and root rot was more severe during high temperatures.

Field plots established in New Hampshire in May 1963 were harvested at 4-5 week intervals beginning July 2. Samples of roots obtained at 4 different times during the growing season showed that root rot was greater on plants sampled in October than on those plants sampled previously.

Seedlings of 61 seed sources of white clovers were tested in New Hampshire for tolerance to low temperatures. Percentage survival varied from 0 to 67%. Resistant, susceptible and standard selections were vegetatively increased and transplanted to the field in 1962. Ratings in 1963 showed that plants selected for resistance had a higher percentage survival in the field than standard selections. This indicates that the laboratory method of testing may be useful for screening studies.

Crop rotation plots in Delaware seeded in 1962 with Pennscott clover and Vernal alfalfa were examined for plant populations in May, 1963. Little difference was found in Vernal alfalfa stands on any rotation series. With Pennscott clover, poorest stands were in plots having had crimson clover the previous 8 years; the next poorest stands were in plots having had tomatoes for 8 consecutive years; best stands were in plots previously in corn for 10 consecutive years.

Histological studies in Rhode Island indicated that resistance of alfalfa to fungus penetration by Fusarium sp. was due to occlusion in the vascular tissues by tyloses. To attempt to explain morphological and physiological (pathogenic) variability of isolates, their nuclear condition was examined

in vivo by phase contrast microscopy. It was found that fungi-toxic chemicals influenced septum formation and consequent nuclear number per "cell". Likewise, the average nuclear number per hyphal tip cell could be significantly changed by either the concentration of nutrients, the pH of the substrate, or the presence of a growth regulator.

USEFULNESS OF FINDINGS:

The consensus of the reports from most of the states indicates that species of Fusarium are the most common fungi isolated from diseased roots and crowns of alfalfa and clovers. This information is very valuable because now a concentrated effort in the participating states will be directed towards more complete understanding of how and why this group of fungi cause rotting of alfalfa and clovers. This does not imply that other root and crown rotting organisms will be completely ignored.

The complexity of the root and crown rot problem is emphasized by the finding that insects are a prime factor in stand depletion of red clover.

The findings that severity of root and crown rot is increased with increased frequency and closeness of cuttings and in stands established in fields previously cropped to legumes are significant in terms of management practices.

WORK PLANNED FOR NEXT YEAR:

Delaware---Research will be initiated on the histopathology and cytopathology of red clover roots after invasion by selected pathogens. Research will start on the determination of host response upon inoculation with various dosage levels of various combinations of pathogens.

New Hampshire---The effect of different cutting heights on development of root rot will be determined on: a) second year stands of white clover in the field and b) red and white clovers grown in the greenhouse. The pathogenicity of selected fungi will be determined on clover roots growing in perlite. Testing and selection of white clover plants for tolerance to low temperatures under simulated and field conditions will be continued. Efforts to develop a histological method suitable for determining anatomical changes in clover roots due to winter injury will be continued.

New Jersey---Studies will be continued on the nature and influence of root exudates on selected fungi and antagonistic actions between selected fungi. Study of the effect of different environmental factors on fungus population changes will also be continued.

New York---Further studies will be made on pathogenicity of isolates, the role of calcium in relation to susceptibility of alfalfa seedlings and enzyme activity of fungal isolates, and nature of enzymes produced by selected fungal isolates.

Pennsylvania--The interaction of varying combinations of Fusarium sp. in the parasitism of alfalfa and clover roots will be studied further. In order to reduce the possibility of contaminations, these studies will be conducted in germ-free isolators. Should combinations showing strong correlations be obtained, exploratory studies concerning the nature of the interactions will be undertaken.

Amino acid and vitamin components of alfalfa and red clover root exudates will be identified and the influence of these fractions on the parasitic and pathogenic capabilities of soil fungi studied.

Rhode Island---Studies in vivo of the nuclear/cell differences in fusarial hyphal tips and their potential relation to pathogenicity will be continued. The reaction of alfalfa root tissues to hyphal tips and to metabolites will be observed. Biocides and growth regulators as alfalfa root rot deterrents will be evaluated.

West Virginia---Red clover and alfalfa field plots will be established and will include plots treated with a methyl bromide fumigant and untreated plots. They will be sampled in much the same way as previously described but emphasis will be placed on more frequent sampling during the early stages of growth.

Title: PROJECT NE-48 - SOIL-PLANT-WATER RELATIONSHIPS

Contributing Project: Pa. 1437 - The Dynamics of Water in
Soils in Estimates of Plant and Soil Parameters

Leader: L. T. Kardos

The forage irrigation plots were used as a test area to secure information on the orders of magnitude of soil-root flux of soil moisture and of soil-soil flux of soil moisture under natural rainfall and at two levels of supplemental irrigation. The crops involved were alfalfa, alfalfa-bromegrass, alfalfa-orchardgrass, birdsfoot trefoil, birdsfoot trefoil-bromegrass, birdsfoot trefoil-orchardgrass, bromegrass, orchardgrass, ladino clover, and ladino clover-orchardgrass. Bouyouces moisture blocks were used at the 4" depth and the Chicago-Nuclear neutron moisture meter at sampling depths of 12", 20", and 28".

Although not conclusive, there are indications that, where root extraction causes a large gradient between depth zones, an appreciable inter-zone flux may occur as reflected in the relatively larger net flux out of the 24-32" zone of the birdsfoot trefoil and bromegrass plots. At the beginning of the period the relative gradients expressed in volume percent water differences between the 16-24" and 24-32" zones were 7.5% and 2.5%, respectively, for the birdsfoot and bromegrass plots and only 1.0% and 0.5%, respectively, for the orchardgrass and alfalfa plots. The data further indicate that large differences, 7% to 10% water by volume between the 8-16" and 16-24" zone, persisted for periods of 40 to 50 days. These persistent differences were in essence persistent gradients between these two zones. Two possible interpretations

of this persistent gradient are: (1) root withdrawals from the 8-16" zone and flux from the 8-16" into the 0-8" zone are being compensated by flux from the deeper zones or (2) flux from the 8-16" zone to the root and to the 0-8" zone become nil and flux from the deeper zones is inadequate to readjust the gradient. Examination of the data for the mixed grass-legume hay stands and the ladino and ladino-orchardgrass plots is continuing and additional drying cycles will be examined. However further research will be necessary to firmly establish the relative importance of the various dynamic processes involved. Data on moisture changes to a greater depth will be important particularly for the alfalfa, brome grass, and birdsfoot trefoil which showed significant depletions of the water in the 24-32" zone.

The study of the dynamics of water transmission through glass bead and soil column systems in the laboratory has been initiated but no data are available.

USEFULNESS OF FINDINGS:

The relative importance of depth and degree of root occupancy of the profile in decreasing the need for supplemental irrigation can be more adequately evaluated by segregating the contribution of interhorizontal flux of soil water in supplying water to the growing plant.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: APPLICATION OF HIGH RATES OF FERTILIZER TO ALFALFA

Leaders: R. I. Munsell and L. Barber

Vernal alfalfa received seven rates of limestone (1-16 tons) and seven rates of superphosphate (200 to 1600 lb.) during establishment in 1959. Annual applications of 200 lb. per acre of superphosphate were used as a check treatment. Stands were good in all plots during the fourth year, 1963. Yield differences did not occur among treatments in the first 3 seasons. During the fourth season yields were not changed by differing lime levels but yields from plots with only 200 lb. initial phosphate application were less than all other phosphate levels including plots receiving annual applications of 200 lb. These data indicate that phosphate may be added before seeding as a "stockpile" in sufficient amounts for the duration of the stand without loss in yield.

Title: RATES OF LIME

Leaders: R. I. Munsell and L. Barber

Alfalfa was established on previously unlimed soils (pH 4.7) following application of dolomitic limestone at rates from 2 to 8 tons per acre. In the fourth harvest year a definite trend appeared as plots with low lime levels had significantly lower yields than plots with high lime levels. Application of 2 tons per acre maintained good yields for 2 years. By the third year 3 tons per acre were needed and in the fourth year 6 tons initial application were needed to maintain highest yields.

Title: GRASS VARIETY TRIALS

Leader: D. D. Wolf

Twenty three grass varieties and Vernal alfalfa were tested in the first harvest season for hay yield performance. Bromegrass, timothy, orchardgrass, reed canarygrass, and tall fescue were evaluated. Each variety was harvested when highest yields of good quality hay could be obtained. One hundred pounds

of N were applied in 3 applications to all grasses. Alfalfa yielded more than 16 grasses and was equal in yield to 2 timothy and 5 brome grass varieties. Clair timothy was superior to other timothy varieties but differences among varieties of other species were not significant. Differences among species were significant.

Title: ALFALFA PLANT POPULATION

Leader: D. D. Wolf

Alfalfa was thinned by hand and populations achieved were .9, 1.4, 2.8, 4.2, 7.2, 9.7 plants per square foot. Orchardgrass was overseeded as a split plot feature. Yields in the first harvest year were greatly reduced by the presence of fewer than 2.8 plants per square foot in pure stands. Where grass was present yields were greatly reduced by the presence of fewer than 4.2 plants per square foot.

Title: EFFECTS OF HIGH RATES OF NITROGEN AND IRRIGATION ON YIELD AND CHEMICAL COMPOSITION OF FORAGE GRASSES

Leaders: E. R. Larssen, E. J. Rubins, and J. R. Guttay

The third and final year of this field study was completed in 1963.

Yield of orchardgrass was not increased by rates of nitrogen fertilization greater than 375 pounds per acre in 1961 and 300 pounds in 1962 and 1963. There was appreciable accumulation of nitrate in the forage when nitrogen application equaled or exceeded 500 pounds. Nitrogen deficiency was noted in all 3 years at the lowest nitrogen rate (125 pounds in 1961; 100 pounds in 1962, 1963). Orchardgrass responded significantly to irrigation only in 1963.

Timothy did not respond to irrigation. Yield increased with nitrogen fertilization up to 200 pounds in 1961 and up to 300 pounds (the highest rate) in 1962 and 1963. Tissue nitrate levels increased as the rate of nitrogen fertilization increased. Levels considered safe for animal feeding were exceeded in some cases in 1961 and 1962 but not in 1963.

MAINE

Title: PRODUCTIVITY OF FORAGE SEEDINGS

Leaders: C. S. Brown and R. F. Stafford

The project (1962 Annual Report, page 42) to determine the potential productivity of oats-alfalfa-grass seedings was continued, with a seeding made on May 25. Comparisons were made of DuPuits and Narrangansett alfalfa, sown in simple mixtures with Saratoga brome, Climax timothy and Masshardy orchardgrass. Garry oats at 70 lbs. per acre was used as the companion crop and harvested at full head state on July 17.

Oats contributed over 2 tons of dry matter, but suppressed alfalfa yields about 0.5 tons in the July harvest. Excellent stands of alfalfa were secured in spite of the vigorous oat crop. There was little residual effect of oats on alfalfa yields in the second harvest.

Oats suppressed spring weeds (chiefly lambsquarter) nearly as much as an application of 2,4-D Butyric. Oats completely excluded barnyard grass in the second harvest, in contrast to the no-oats plots with or without a spring herbicide.

Poor establishment of grasses in competition with vigorous oats and alfalfa, continues to be the major problem. Orchardgrass proved superior to either brome grass or timothy, although its total yield in two cuttings was only 0.4 ton in the no-oat treatments and 0.1 ton in the oat treatments. An application of fertilizer N in the fall of the seeding year has had some beneficial effect on grass recovery.

Title: FORAGE HANDLING SYSTEMS FOR DAIRY FARMS

Leaders: R. J. Rowe, B. E. Plummer and B. L. Bondurant

Work was continued on a system of hay harvest involving a two step field procedure consisting of cutting and conditioning with a flail type forage harvester followed by field pickup with a flail harvester at 35-40% moisture content. Considerable improvement in handling was obtained by substituting a forage blower for the previously used elevator. A major limiting factor is the long lengths of cut material resulting from field pickup with a direct throw type of flail harvester. Future work planned will determine bulk specific volume and unloading rates which can be obtained using a range of harvester types available.

MARYLAND

Title: RED CLOVER BREEDING INVESTIGATIONS

Leader: E. H. Beyer

The polycross progenies from 24 red clover clones were evaluated and compared with the variety Chesapeake. A number of the polycross progenies exhibited a higher mean number of plants per plot after two years and yielded more forage than the check variety. Based upon these results, red clover synthetics will be constituted and tested.

Title: FORAGE CROP VARIETY EVALUATION IN MARYLAND

Leaders: E. H. Beyer, A. M. Decker and N. A. Clark

Twenty-eight alfalfa varieties and strains were established at two locations. These include commercial entries that may be of interest in the state.

Title: NUTRIENT BALANCE IN ORCHARDGRASS AS RELATED TO DIFFERENTIAL FERTILIZATION

Leaders: C. B. Kresge and V. A. Bandel

Differential amounts of phosphorus, potassium, and magnesium were topdressed on orchardgrass in 1963 (pounds per acre of nutrients: P - 0, 20, 40, and 60; K - 0, 40, 80, 160, and 240; and Mg - 0, 10, 20, 40, and 80). A uniform rate of nitrogen was applied. Three cuttings were made and plant tissue samples were taken for analysis of N, P, K, Ca, and Mg. A positive yield response to applied phosphorus was obtained. No significant response to potassium or magnesium occurred. Evaluation of plant analysis data is expected to reveal interesting nutrient balance relationships in orchardgrass.

Title: RESPONSE OF BERMUDAGRASS TO VARIOUS RATES OF POTASSIUM AND NITROGEN

Leaders: C. B. Kresge and A. M. Decker

Much of the Midland bermudagrass in the experimental area (1960 Annual Report, pages 67-68) was winterkilled in 1963. Consequently, no dry matter or plant composition data were obtained. Index readings of winter survival were taken on each plot. The bermudagrass survived best (1) when not overstimulated by nitrogen late in the growing season and (2) at any one rate of nitrogen when the applied nitrogen to potassium ratio was 2.4 to 1.

Title: RESPONSE OF ORCHARDGRASS TO VARIOUS SOURCES OF NITROGEN AND TIME OF THEIR APPLICATION

Leader: C. B. Kresge

Various sources of nitrogen were applied at different times to orchardgrass as previously outlined (1961 Annual Report, page 46). Results in 1963 were much like those in 1962 (1962 Annual Report, pages 49-50) with the following exceptions: (1) urea compared favorably with other sources in 1963 and (2) the highest rate of ureaformaldehyde somehow restricted plant growth preceding the first cutting in 1963. The investigation was modified late in 1963 by replacing the September 15 nitrogen application with a November 22 nitrogen application. Data obtained during the past 2 years support the conclusion that soluble nitrogen, other than the nitrate source, can be applied economically to orchardgrass in late fall or early winter for growth the next spring.

Title: EFFECT OF PHOSPHORUS ON THE GROWTH AND DEVELOPMENT OF ALFALFA

Leaders: C. B. Kresge and D. F. Champion

Treble superphosphate (TSP) and diammonium phosphate (DAP) were banded or broadcast with banded or broadcast alfalfa seed, respectively. Rates were 0, 46, 92, and 184 pounds of P_2O_5 per acre. Seedling establishment observations were made during the fall of 1963. Alfalfa receiving no P was markedly inferior to that receiving P. Bandseeding resulted in a better stand than broadcasting seed. One difference caused by phosphorus sources was a temporary one between high rates of banded TSP and DAP. Initial nodulation and early growth of plants appeared to be slightly retarded by DAP when compared to alfalfa receiving TSP. Alfalfa receiving 46 pounds of P_2O_5 from DAP was initially superior to alfalfa receiving the same rate from TSP when the broadcast method was used. Subsequent observations on growth and development of alfalfa will be made.

Title: THE COMPARISON OF NITROGEN FERTILIZED GRASSES WITH A GRASS LEGUME MIXTURE FOR LACTATING COWS

Leaders: N. A. Clark, R. W. Hemken and J. I. Leslie

Pastures consisting of a comparison of orchardgrass-ladino clover and pure orchardgrass fertilized with three rates of nitrogen (100, 200, and 300 pounds per acre) were managed by grazing with lactating dairy cows in 1960, 1961, and 1962. In 1963 pasturing was discontinued and plant samples obtained the previous year were ground and chemically analyzed.

Title: FERTILITY AND CLIPPING MANAGEMENT EFFECTS ON THE PRODUCTIVITY AND PERSISTENCE OF ANNUAL PASTURE GRASSES

Leader: N. A. Clark

Sudangrass, pearl millet, and a commercial sorghum-sudangrass hybrid are being compared under two levels of nitrogen fertilization, two cutting heights (18 and 30 inches) and three stubble heights (2, 4, and 8 inches). In 1963 yield response was comparable to that obtained in 1962. Pearl millet was more productive than sudangrass at the 30-inch cut. Under the dry conditions, as in 1962, the hybrid produced approximately twice as much dry matter as the other two forages. Neither nitrogen levels nor stubble heights were significant.

Title: SOD SEEDING ESTABLISHMENT STUDIES

Leader: A. Morris Decker

A uniform planting of Midland bermudagrass was fertilized with 200, 400 and 800 lbs. of N per acre for the third growing season. Rye was seeded into the undisturbed sod for the third fall and fertilized with 0, 20, 40 and 80 lbs. of N per acre at seeding time. Rye vetch was seeded into a set of plots which received 200 and 400 lbs. of N on the Midland. A third set of plots received the 200, 400, and 800 lbs. of nitrogen but were not sod-seeded. Total yield increased with each increment of added nitrogen. Vetch, for the first time in the study, contributed significant amounts of forage during the spring harvests. Indications are that at least 400 lbs. of N are required to provide adequate growth of both the summer-growing Midland and the fall and spring growing rye.

Birdsfoot trefoil was successfully established in bluegrass sod for the third year with early fall seedings. A spring seeding was made and found to be as good as fall seeding and slightly superior for some treatments. Further modification of the experimental sod-seeder resulted in a more simple unit. This unit was as good as or better than the original disk type opener which proved to be so successful.

Title: RESPONSE OF MIDLAND BERMUDAGRASS TO TWO SOURCES OF NITROGEN, THREE RATES OF NITROGEN AND THREE LEVELS OF LIME

Leaders: A. M. Decker and J. H. Axley

A uniform planting of Midland bermudagrass with a pH of 6.5 was fertilized for the second year with 200, 600 and 1800 lbs. of nitrogen per acre with both ammonium nitrate and ammonium sulfate sources. Some plots received no additional lime, some received a theoretical amount needed to correct nitrogen acidity while the third group received twice the required lime.

Total yields in 1963 range from 0.59 tons with no lime and no nitrogen to 6.86 with 600 lbs. of N as ammonium nitrate with twice the required lime. There was a reduction in yield when nitrogen was increased from 600 to 1800 lbs. N per acre. This was true whether lime was applied or not. In every case, yields from the ammonium nitrate plots were higher than from the ammonium sulfate fertilized plots. Nitrogen recovery data are being obtained along with the effect of these treatments on soil pH and nutrient availability.

Title: EFFECTS OF CLIPPING HEIGHTS AND FREQUENCY OF HARVEST ON THE PERFORMANCE OF MIDLAND BERMUDAGRASS

Leader: A. M. Decker

All treatments were left unfertilized and uniformly harvested during the 1963 growing season in order to measure residual nitrogen, clipping frequency and clipping height treatment effects imposed during the past three years (1960 Annual Report, page 71). Two harvests were made. The largest residual effect was from nitrogen fertilization both in terms of total production and weed-free forage. Yields were slightly higher for the less frequently harvested plots as well as for those plots cut at the higher stubble height. However, these differences were rather small. Plant tissue analyses are being completed prior to publication of data.

Title: DIFFERENTIAL HARVESTING MANAGEMENT OF RED CLOVER AND RED CLOVER-TIMOTHY STANDS UNDER THREE LEVELS OF FERTILIZATION

Leaders: A. Morris Decker and L. R. Wade

Uniformly seeded plots of Chesapeake red clover and Chesapeake-Clair timothy were seeded in the spring and fall of 1963. Additional spring and fall plantings are being made in 1964 at a different location. The first harvest in the spring will be made at the bud, early bloom and full bloom stages. Second and subsequent harvests will be made at 1/2 bloom. One third of the plots will not be fertilized, 1/3 will be fertilized at soil test recommendations, and 1/3 at twice the recommended amount. Dry matter yields, botanical composition, chemical composition and stand count data will be obtained.

Title: CULTURAL PRACTICES IN ALFALFA IN RELATION TO ALFALFA WEEVIL POPULATIONS

Leaders: A. L. Steinhauer, University of Maryland, C. C. Blickenstaff and J. Huggins, Agricultural Research Service, Beltsville, Maryland

The results of the first year of this study showed that method of cutting (conventional mowing and raking, flail cutting, and cutting with direct removal of alfalfa) had no effect on weevil populations. Early cutting (full bud stage) proved to be an effective means of lowering populations of weevils without chemical treatment. Early cutting followed by a stubble spray immediately after cutting was no more effective in killing weevils than cutting alone. In both cases weevil populations (larvae) were the same one week after cutting.

Title: INSECTICIDAL CONTROL OF THE ALFALFA WEEVIL

Leaders: A. L. Steinhauer, University of Maryland, C. C. Blickenstaff and V. E. Adler, Agricultural Research Service, Beltsville, Maryland

Fall applications of organic phosphate insecticides alone and in combination with various extenders failed to give adequate control of alfalfa weevil. With the exception of heptachlor and telodrin, the only application of insecticide in the fall that gave adequate control was methoxychlor at 3 lbs./acre.

Screening of compounds for control of larvae in the spring yielded the following materials, which are very promising: Amer. Cyan. 47772 (1/4 lb./acre), Gen. Chem. 4072 (1 lb./acre), and Shell SD 7438 (1 lb./acre). Bacillus thuringiensis, a bacterial pathogen of many insects, failed to exert much effect.

Title: PASTURE EVALUATION USING BEEF STEERS

Leader: A. Morris Decker

Twenty-five acres of Midland bermudagrass were established and uniformly treated during the summer of 1963 in preparation for experimental grazing during 1964. Complete relocation of fences, water lines, etc., was necessary because of state highway expansion. Thirty-nine head of choice Angus steers averaging 400 pounds were purchased in October 1963 and uniformly wintered in preparation for grazing studies. Pastures will be grazed at two nitrogen levels and two grain levels. Because of the 1963 drought experimental grazing will be delayed until mid-summer 1964 in order to obtain uniform stands for all treatments.

Title: THE EVALUATION OF SUMMER ANNUAL PASTURES FOR LACTATING DAIRY COWS

Leaders: N. A. Clark, R. W. Hemken and J. H. Vandersall

Piper sudangrass and Gahi No. 1 Pearl Millet were compared as a summer annual pasture for dairy cows. In yield of dry matter, animal carrying capacity, and amount of milk produced, there was no difference between these two pastures. However, butterfat production was significantly lower than that of cows grazing sudangrass.

MASSACHUSETTS

Title: RELATIONSHIP OF FRUCTOSAN TO HARVEST MANAGEMENT, LEVEL OF FERTILIZER N, AND RECOVERY OF ORCHARDGRASS

Leaders: Mack Drake and W. G. Colby

The rate of recovery of Mass Hardy orchardgrass was reduced most seriously in the treatment which combined high N and delayed initial harvest. Serious injury occurred most frequently after the second harvest. Some plants died, but with many plants only the centers of the crowns died and regrowth slowly developed around the outer edge of the crown producing a "bird nest" pattern.

We believe in the theory that carbohydrate level in the basal tissue is an important source of reserve energy to support the rapid vegetative growth, immediately following the harvest of orchardgrass. Baker and Garwood (J.B.G.S. 16:1961) demonstrated that fructosan represents the major portion of soluble carbohydrates in basal tissue of orchardgrass and serves as an indicator of carbohydrate reserves.

At Amherst, 0 to 1.5 inch zone of basal tissue was higher in fructosan and was more sensitive to treatments than the 1.5 to 3.0 inch zone. At each of the first 4 harvests (5 total) the fructosan content in the basal tissue was reduced by added increments of N. Fructosan in the first harvest at the early initial stage of growth (boot on May 28) was reduced from 8.4 to 2.7, 2.4, 2.2 percent by 50, 100, and 150 pounds of N respectively and from 9.8 to 7.0, 3.9 and 3.5 percent as initial harvest when plants were in early flower (June 7). Since fructosan was higher at each level of N for the more mature plants, it appeared that carbohydrate reserves were being increased during the period May 28-June 7.

The second harvest was made after a one month recovery period for plots initially harvested at the early (May 28) and normal (June 7) stage of growth. Fructosan was reduced by rates of N as in the initial harvest.

However, in contrast to the pattern of fructosan content at the initial harvest, at the second harvest, fructosan was high in the basal tissue of those plants harvested initially at a less mature stage of growth. In the initial harvest at the boot stage, the cutter bar was above more of the growing points than harvest at flowering. Cutting above the growing points favored

more rapid re-establishment of leaf surface and could result in a greater production of carbohydrates. More rapid re-establishment of the forage canopy favorably lowered soil temperatures, probably resulting in greater gain in soil moisture by vapor transfer. Growth recovery and yields following 2nd and 3rd harvests were greater with the higher levels of fructosan, for each level of applied N.

Title: FORAGE CROP INSECTS IN MASSACHUSETTS DURING 1963

Leaders: F. R. Shaw and W. H. Ziener

Population Studies of Insects of Forage

A survey of forage crop pests was made during April - June 1963. The following data were obtained:

Name of insect or insect group	Percent of total
Pea aphid (<u>Acyrtosiphon pisum</u>)	43.6
Beetles	
Alfalfa weevil (<u>Hypera postica</u>)	38.0
Clover root curculio (<u>Sitona hispidula</u>)	2.5
Wireworm adults (<u>Elateridae</u>)	1.4
Miscellaneous beetles	1.0
Plant bugs	
Mainly the tarnished plant bug <u>Lygus lineolaris</u>	4.1
Leafhoppers	
<u>Aceratogallia sanguinolenta</u> , <u>Macrosteles fascifrons</u> , <u>Draculecephala</u> spp.	3.7
Miscellaneous	
Grasshoppers, caterpillars, sawflies	2.1
Beneficial arthropods	
Coccinellids, <u>Nabis</u> sp., chrysopids, spiders	3.6

Of particular note is the great increase in numbers of the alfalfa weevil. In our 1962 fall survey this represented only 1.8 percent of all insects, whereas in the spring (1963) survey it rose to 38 percent.

The potato leafhopper was not so abundant in 1963 as it had been in previous years. The leafhopper Errastunus ocellaris continues to be abundant in Berkshire County.

Seasonal Life History of the Alfalfa Weevil

We observed adults and first and second instar larvae but no over-wintering eggs in Hampden County on May 1. The first egg punctures were observed on May 17; they averaged 8.0 eggs per puncture. By May 31 populations of 37 adults and 477 larvae per 100 sweeps were collected in Hampden County. Pupation was first noted on May 27 in Bristol County, May 31 in Hampden County and June 5 in Berkshire County. The maximum population ever collected, 2,400 specimens per 100 sweeps, was obtained on June 5 in Berkshire County. Newly emerged adults were collected on June 13 in Hampden County. During the remainder of the season, alfalfa weevil populations were minimal in Hampden and Hampshire counties. In Berkshire County populations dropped somewhat between July 30 and August 27 but increased in September and continued to be high until November 19. Maximum adult populations of 160 per 100 sweeps occurred on November 10.

In order to determine the extent of fall oviposition, samples of 50 stems were collected and examined in the laboratory from October 2 to November 10. The average number of eggs per puncture decreased from 10.2 on October 2 to approximately 6 during the remainder of the observation period.

Parasites of the Alfalfa weevil

Recoveries of Bathyplectes curculionis were obtained from liberations made in 1962 in Leverett and in Seekonk, Massachusetts.

We reared Itoplectis conquisitor from pupae of the alfalfa weevil collected in southern Berkshire County. An egg parasite, Patasson luna was also reared from eggs collected in the same area.

We also found some adults which were fungus infected. Specimens were sent to California and one fungus was identified by G. A. Marsh as Beauveria bassiana. A second fungus proved to be a species of Fusarium which Dr. Marsh indicated was a secondary saprophyte.

A first instar dipterous larva, probably a Tachinid, was recovered from a pupa of the alfalfa weevil but we were not able to rear it to the adult stage.

Ecology of the Alfalfa Weevil

The alfalfa weevil was reared in the laboratory under conditions of controlled temperature, humidity, photoperiod and narrow band wavelengths of light.

Development was observed at temperatures of 25°C, 30°C and 35°C was 26, 18.3 and 16.7 days respectively. A relative humidity of 60 percent was more favorable than relative humidities of 40 and 80 percent. The only effect of photoperiod observed was that prepupal development was more rapid at the 15 hour exposure than at 9 hour exposure. Blue light increased the developmental periods of larvae, prepupae and pupae.

Ability of Alfalfa Weevil to Develop on Different Legumes

Twelve different legumes were included. The alfalfa weevil completed development from first instar larvae to adults only on alfalfa, ladino clover, alsike clover and sweet clover.

Insecticide Investigations

Cygon, methoxychlor, diazinon, Guthion and Methyl-ethyl Guthion were applied as stubble treatments. Methoxychlor was applied at 1.5 lbs. actual per acre, the other insecticides at 0.5 lbs. actual per acre. Collections were taken at 1, 5, 10 and 15 days post treatment. For alfalfa weevil and leafhoppers, all were significantly better up to 10 days than the controls. However, by the 15th day, there was no difference in populations in treated and control plots. Methoxychlor was not effective against aphids.

Pesticide Residue Studies

Heptachlor was applied as a heptachlor fertilizer mix in the fall of 1962 by commercial applicators. Treatment was 1.0 pound of heptachlor per acre. In the spring of 1963, samples of alfalfa were cut in treated fields and analyzed by Dr. Donald Lisk of the Cornell Pesticide Residue Laboratory. Residues up to 44 parts per billion of heptachlor epoxide were recovered.

Cygon and SD 7438 were applied to various forage crops and their rates of disappearance determined. The data will appear as a scientific note in the Journal of Economic Entomology.

NEW HAMPSHIRE

Title: THE IMPROVEMENT OF WHITE CLOVER

Leaders: G. M. Dunn and R. A. Kilpatrick

Ten diallel single crosses of ladino clover yielded 1.96 tons per acre in the Syn 1 and 2.04 tons in Syn 2, a nonsignificant difference. Yields were relatively low because of extensive drought.

In a growth chamber study, most of the stolon branching occurred on the older half of the stolon. Common white clover had more stolon branching than the ladino type.

Survival of ladino plants in the field was somewhat better for those which had previously been found resistant to low temperatures in a freezing chamber.

Larvae of Sitona hispidula and S. flavescens emerged after 14 and 18 days, respectively, in nutrient agar tubes. Some larvae fed extensively on secondary roots, but died within 48 hours.

A test tube method was used to evaluate toxicity of herbicides on legumes. Symptoms of root necrosis or callus development were noted within 10 days. Red clover was more susceptible to atrazine than alfalfa; the reverse was true for 2,4-D.

Title: IMPROVEMENT OF SMOOTH BROMEGRASS, RED CLOVER AND ALFALFA

Leaders: G. M. Dunn and L. J. Higgins

Average yields in 1963 for 15 diallel brome grass crosses were 3.55 in Syn 1 versus 3.05 tons/acre in Syn 2. A few of these single crosses look promising for brownspot resistance, leafiness and recovery.

Increased light intensity had no effect on percent seed set of brome grass in the greenhouse.

No significant contamination occurred on yellow brome grass mutants planted 50-750 feet away from a dominant green clone. In another test, the same mutants were significantly contaminated by pollen from one half acre of dominant green plants when planted 450 feet away from them, the maximum distance available.

Additional selfing, sibbing, and crossing were continued with chlorophyll, dwarf, and rolled leaf mutants of brome grass.

Total chlorophyll content has been reduced by a factor of 4 by selection for light yellow brome grass mutants.

Additional seed was obtained of New Hampshire red clover by crossing isolated plants with bees in the greenhouse.

NEW JERSEY

Title: ALFALFA VARIETY TRIAL (DAIRY RESEARCH CENTER, BEMMERVILLE, N. J.)

Leader: C. H. Ramage

The trial was established in 1960. Included were Atlantic alfalfa, Maliani (an Italian import), and Orchies (a French variety). Yield results for 1961, 1962, and 1963 are summarized in the following table. Three cuttings have been made each year.

Alfalfa variety trial - dry matter yields

	<u>Atlantic</u> lb/acre	<u>Orchies</u> lb/acre	<u>Maliani</u> lb/acre
1961	10,259	10,127	9,049
1962	8,935	8,535	7,917
1963	10,603	9,868	11,045
Total	29,797	28,530	28,011
Av.	9,931	9,510	9,370

Title: MIDLAND BERMUDAGRASS

Leader: Robert W. Duell

Widespread winterkilling of Midland bermudagrass was experienced throughout central New Jersey for the first time since this hybrid was introduced to the area in 1954. In more northerly locations in the state where snow cover was more prevalent and in more southerly locations, survival was good to excellent.

Fertility experiments, control experiments, and establishment experiments in central New Jersey were lost. New plantings were initiated.

Simazine, which had proved satisfactory in Midland bermudagrass establishment studies previously, failed to control weeds during the dry season of 1963. Dichlobinel (casaron), which had proved effective previously, gave good selective control during this droughty season.

Title: GRASS FERTILIZATION

Leader: Robert W. Duell

Established orchardgrass stands were severely depleted during the winter of 62-63 where potassium fertilizer had been withheld for three years, and N at 200 lb/a/yr from NH_4NO_3 had been applied (half in early April, half in early June). Neither Kentucky bluegrass nor tall fescue showed winter injury under similar treatments. In comparison with plots receiving KCl, the Kentucky bluegrass receiving only NH_4NO_3 sustained more serious drought injury.

Orchardgrass seedlings, adequately fertilized and properly started, were severely winterkilled, especially in elevated portions of a fairly level field. There was no winterkilling of the seven other forage species. The surviving orchardgrass and the reed canarygrass failed to elongate internodes and form seedheads during the 1963 season.

Title: SILAGE INVESTIGATIONS

Leaders: M. A. Sprague and B. B. Taylor

All corn and sorghum silages from 1962 harvests were of excellent quality. Corn yielded twice that of sorghum and sorghum responded far more readily to nitrogen fertilizer than corn. Nitrate content of all forages was well within safe limits. Dry matter losses in corn and sorghum were influenced more by maturity than by nitrogen fertility. Early maturity sorghum lost more dry matter than that cut late. Nitrogen fertilizer increased protein content as did early maturity. Protein loss during storage was much greater from early cut forage than late and this was more pronounced with sorghum than corn.

pH electrodes sealed in the silages permitted monitoring 1963 changes. In comparison of an agar salt bridge with the calomel electrode variations did not exceed 0.1 pH unit. Rate of drop of pH was greater at higher fertility than low, and more rapid at late maturity than early. Low ambient temperature at the time of harvest slowed the rate of fermentation. Sorghum fermented more slowly than orchardgrass. Corn was not tested. In greenhouse studies sorghum was demonstrated to be a nitrate accumulator at high rates of fertility. Nitrates were also higher in younger maturity forage than at later maturity. Green-cut young alfalfa can be stored at cool (32-34°F) temperatures in an aerobic condition for 3 months with only about 0.15 units change in pH.

NEW YORK (CORNELL)

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS

Leaders: R. P. Murphy, R. E. Anderson and C. C. Lowe

Selfed and open-pollinated progeny of R3 generation timothy clones were established in the field in 1963. Several potentially useful agronomic types as well as genetic marker selections have been obtained in advanced generations of irradiated material. An unselected random sample is being maintained for cytological study of chromosomal changes following different dosage and types of irradiation.

Inheritance studies with nine genetic marker clones of bromegrass involve the following materials: clone materials of the nine clones and their full sib relatives; selfed seed; open pollinated seed; selected single crosses among the parent clones.

A study has been completed on estimation of genetic variance components from a mating scheme of double-crosses among parent lines. Five quantitative characters in alfalfa were studied in two populations of parent plants and the results used to estimate genetic variances under an assumed autotetraploidy model. While the genetic variances for the two populations compared as expected, a pattern of negative estimates for components suggested bias in the estimates due to epistasis. It was concluded that while double crosses in tetraploids may be a desirable breeding procedure it is not a favorable mating scheme for quantitative genetic study due to: (a) the large number of crosses derived from a small number of parent lines, (b) difficulties in statistical analysis and (c) bias effects on genetic variance estimates due to epistasis.

Genetic studies on white flower color and white seed coat color in alfalfa have been concluded. Ten parent plants from a (white-flowered, white-seeded x white-flowered, brown seeded) cross were used to construct F₂ and backcross families for studying these two characters. White flower color was found to be conditioned by the homozygous condition of genes at either or both of two loci. This evidence of complementary gene action agrees with previous studies that have postulated tetrasomic inheritance. White seed coat color appeared to be determined by the homozygous recessive condition at one locus with tetrasomic inheritance. Genetic studies on a white-flowered chimera obtained on a purple-flowered clone indicated a simplex condition on one of the two genes determining purple flower color.

Observations in broadcast plantings of several creeping-rooted combinations point to the necessity for increased vigor to successfully establish seedlings of this material. Several creeping-rooted synthetics are now under evaluation to observe expression of the creeping character under the competition of broadcast plots and normal harvest management.

Studies on self and cross fertility for six selected clones from the variety Narragansett show a relatively high heritability for ability to set seed under greenhouse conditions. Pollen tube studies using a fluorescence technique were made on the parent clones. Pollen tube penetration was found to be somewhat restricted in low seed-setting clones but pollen tube inhibition was not the major factor limiting quantity of tubes present in the ovary. Pollen tube penetration was usually greater following cross-pollination than after self-pollination. Low seed set of some clones was at least partially due to low frequency for ovule fertilization. Abortion of fertilized ovules was greater following selfing than crossing. Number of ovules per ovary was not highly correlated with seed set. It was concluded this character had little predictive value.

Title: BREEDING AND STRAIN EVALUATION IN FORAGE SPECIES IN NEW YORK FOR IMPROVED FEEDING VALUE, YIELD, AND SEASONAL DISTRIBUTION OF FORAGE

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy, L. V. Crowder and J. T. Reid (Animal Husbandry) and M. J. Wright and H. A. MacDonald (Agronomy) Cooperating

Alfalfa (1962 Annual Report, page 67)

The 1963 growing season in New York was generally favorable following an unusually severe winter. The very dry season of 1962 and unusual late summer growth may have contributed to winter injury. Older alfalfa stands had greater damage than new seedings; greatest injury was observed where drainage imperfections were present. Spring growth in 1963 was delayed by cool weather. In Central New York, the severity of the 1962-63 winter can be gauged by extensive winterkilling of orchardgrass -- the heaviest kill observed in the past 15 years.

In a series of trials, the wilt-resistant Flamande variety (now released as Saranac) showed appreciable superiority over DuPuits in third harvest year production. Saranac is essentially equal to DuPuits and other Flamande-type alfalfas in establishment and first year production; has shown a distinct advantage in the second year and is clearly superior in the third. Greater persistence of stands assures an additional year of profitable production over DuPuits and similar varieties. Survival and production of Saranac versus other wilt-resistant varieties with different growth types such as Cayuga and Vernal are still uncertain. The marked difference in survival between DuPuits and other wilt-susceptible varieties with different growth type such as Narragansett suggests that Saranac will not be as long-lived as Cayuga or Vernal.

An experimental strain exhibiting the multi-leaf character continues to look very promising for forage production.

Grasses

Orchardgrass was severely damaged by winter conditions in 1962-63. There were some consistent variety differences but areas of complete kill were observed in plots of all varieties. Bromegrass and timothy were not affected by the same conditions.

Variety trials with bromegrass indicate that several experimental synthetics have greater vegetative vigor than Saratoga. Other trials indicate that the vegetative vigor of Saratoga can be a detriment to total production in a mixture as compared to a lower vigor strain such as Lincoln, owing to competition effects with the legume. There is doubt that strains with a higher vigor level than Saratoga actually constitute improvement for bromegrass for it is now used primarily as a companion species for alfalfa.

The decline in use for forage grasses in New York has been reflected in all species but has been greatest for orchardgrass and brome-grass. Current assessment is that factors other than productive capacity for forage are responsible for the decrease in use of these two species in New York. Only a major shift in agricultural practice such as less reliance on forage legumes or a reversal of the current non-emphasis on pastures is likely to produce renewed interest in these species. Potential improvements through breeding appear unlikely to change the current trend in New York for brome-grass or orchardgrass because neither species compares well with timothy for nutritive value when forage is used as hay.

Feeding Trials

Intake and digestion trials with sheep were continued to observe differences in nutritive value between the major forage species used in the Northeast and between variety differences within several species. Comparisons have been made on dried hay for forages grown, harvested, and fed under the same conditions to minimize the confounding of environmental effects with intake value differences.

Replication in time has been used to broaden the base of feeding trial environments. This concept, widely employed in crop production evaluation, has not been a feature of many nutritive evaluation trials with animals. Digestibility values (%DDM) are influenced relatively little by animal variation (either within or between ruminant species) or by differences in feeding trial environments; consequently, an adequate number of animals assigned to each forage will usually give satisfactory control of the existing variation and assure valid digestibility values for the forages. Replication in the sense of animals per lot is adequate for this purpose.

Intake trials are influenced by animal variations and by trial environments. Since there is rather general agreement that intake, rather than % DDM, is the more important component of nutritive value, adequate error control in intake trials is of great importance. Increasing animals per lot is not in itself an effective control of error in intake evaluation since it validates comparisons only within a particular trial. Replication in the sense of increasing both number of animals per lot and increasing number of trial environments for all lots should provide greater error control and give greater significance to the intake values obtained. It is known that minimum numbers (2 sheep per lot in each of 2 replications) are now being employed. Data from trials now in progress should provide information on what the requisite replication is for intake evaluation.

Trials are also in progress to ascertain intake value differences between ruminant species fed under identical trial environments.

Trials are currently in progress for the evaluation of nutritive value for six experimental synthetics of timothy. These are being conducted concurrently with production evaluation of the strains.

Title: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS
ADAPTED TO NEW YORK AND ADJACENT AREAS OF THE NORTHEAST

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy and L. V. Crowder

Evaluation of bromegrass polycross progenies in rows under mixture competition for increased management tolerance is being continued. There was no evidence of stand loss on entries through the second year under severe harvest management. Drouth conditions in 1962 may have prevented normal stress from the described combination of competition and harvest management. On the other hand, the excellent survival to date as opposed to previous results may be partly due to growing of the grass in rows versus the random interplanting with the accompanying alfalfa that occurs in seedings made with mixed seed.

Single-crosses of superior progeny-tested clones of timothy are being evaluated in broadcast trials. Similar trials on orchardgrass were lost through winterkill.

Cooperative trials with the USDA on region of adaptation studies with Ranger and Atlantic alfalfa and seed increase studies on Saratoga bromegrass have been completed and are being summarized.

Title: RELATIVE IMPORTANCE OF CELL-WALL DEGRADING ENZYMES IN SOUTHERN
ANTHRACNOSE, SPRING BLACK STEM, AND STEMPHYLIUM LEAFSPOT
DISEASES OF ALFALFA

Leaders: J. G. Hancock and R. L. Millar

A study was made of the importance of some cell-wall degrading enzymes in southern anthracnose, spring black stem, and Stemphylium leafspot caused by Colletotrichum trifolii, Ascochyta imperfecta, and Stemphylium botryosum, respectively. The 3 pathogens differ in the extent to which they attack different organs of alfalfa. C. trifolii is associated principally with petioles and immature stems, A. imperfecta causes spots on leaves and lesions on petioles and stems, S. botryosum is involved principally in causing spots on leaves but also may attack petioles and immature stems.

High pectolytic activity and loss of pectic substances were found to occur in C. trifolii-infected stem tissues, while little or no pectolytic activity or loss of pectic substances could be detected in necrotic leafspots caused by A. imperfecta or S. botryosum. Results were obtained that indicate polygalacturonate trans-eliminase and pectin methylesterase are the principal pectolytic enzymes responsible for the loss of pectic substances in C. trifolii-infected stem tissues. Although all 3 pathogens are capable of producing an exopolygalacturonase in culture, this enzyme was not detected in diseased tissues. Endopolygalacturonase and polymethylgalacturonase were not produced in detectable amounts by these pathogens over a wide range of cultural conditions, which included diseased tissues.

High cellulolytic enzyme activity was associated with C. trifolii-infected stems. A small amount of cellulase (Cx) activity could be detected in leafspots caused by S. botryosum, but not in those caused by A. imperfecta. Cellobiase activity was detected in extracts from diseased tissues infected with all 3 pathogens, but the activity was greatest in C. trifolii-infected tissues. All 3 pathogens, however, produced cellulase and grew well in a defined liquid medium with cellulose as the sole C-source. In addition, cellulase was highly active in extracts of autoclaved shoot cultures.

Although each of the fungi studied has the capacity to utilize native cellulose as the sole C-source, it appears that cellulolytic enzymes are produced in significant amounts only in tissues infected with C. trifolii.

Proteolytic enzymes were detected in Colletotrichum- and Stemphylium-infected tissues, but not in those leaves infected with Ascochyta. The 3 pathogens produce proteolytic enzymes when cultured on autoclaved alfalfa shoots, the greatest amount of enzyme being produced by S. botryosum. The importance of proteolytic enzymes in diseased tissues cannot be completely evaluated because of our imperfect knowledge of the presence of protein in the cell wall, and of the ability of enzymes to penetrate the wall and act directly on the protoplast.

Title: HISTOLOGY OF SUSCEPT: PATHOGEN RELATIONSHIPS OF STEMPHYLIUM BOTRYOSUM AND ALFALFA

Leaders: R. E. Pierre and R. L. Millar

Conidia of Stemphylium botryosum Wallr. germinated on leaves of alfalfa and predominantly entered through stomata but direct penetration occurred also, at the junctures of epidermal cells. Ingress was followed by the formation of thick, bulbous primary hyphae from which smaller secondary hyphae developed 15-18 hr. after inoculation. The secondary hyphae ramified the tissues intercellularly in all directions, following the paths of least resistance. At first, egress was limited to the stomatal apertures, but later conidiophores or hyphae ruptured the epidermis at cell junctures, the latter giving rise to a hyphal network on the leaf surface from which conidiophores subsequently developed. Sporulation was profuse by 168 hr. Conidia frequently gave rise to conidiophores some of which bore secondary conidia.

Although pathologic effects often were microscopically observed in the later stages of development of the primary hyphae, damage was not extensive until secondary hyphae were produced. The first macroscopic symptoms were observed 36-48 hr. after inoculation as yellow flecks within which, brown lesions formed and enlarged to varying degrees. Cellular necrosis was rapid. In the early stages, damaged cells occurred 3-4 cells from hyphae, but later, hyphae were interspersed amongst cells in which deleterious effects were not apparent. The middle lamella was not dissolved and there were only minor degradatory effects on the cellulose wall. The main pathologic effects, therefore, appear to have been exerted directly on the protoplast, probably by toxic products of the susceptible: pathogen interaction.

A study of the response of varieties of alfalfa, red clover, white clover and birdsfoot trefoil to Stemphylium botryosum, S. sarcinaeforme and S. loti revealed a remarkable degree of similarity in the pattern and sequence of development of the pathogens in their main suspects. Ingress of S. sarcinaeforme, unlike S. botryosum and S. loti, was primarily by direct penetration between epidermal cells. Although the pathogens gained ingress into all plants, there was an absence or paucity of development beyond the primary hyphal stage in pathogen: non-suscept combinations. S. sarcinaeforme produced macroscopic symptoms on red clover, alfalfa and white clover, whereas S. botryosum and S. loti were pathogenic only to alfalfa and birdsfoot trefoil respectively.

Title: TRANSMISSION OF SEVERAL FORAGE VIRUSES BY THE PEA APHID

Leaders: L. R. Nault, W. F. Rochow and George G. Gyrisco

Studies carried out during the summer of 1963 involved the transmission of pea enation mosaic virus by the pea aphid. Several new biological relationships were uncovered. The pea enation virus is retained following a molt and was shown to be present in the hemolymph of viruliferous aphids. The results indicate the pea enation virus must circulate through the body of the pea aphid before it is capable of being transmitted.

The pea aphid was unable to acquire virus from peas during 20-60 second probes indicating that the virus is apparently not stylet-borne. However, after a 72-hour acquisition feeding period, the pea aphid was able to inoculate pea enation mosaic virus to peas during 20-60 second inoculation probes. The nymphs were more efficient than adults in their ability to inoculate peas rapidly.

Title: BIRDSFOOT TREFOIL INSECT INVESTIGATIONS

Leaders: G. K. Morris and George G. Gyrisco

One of the most destructive pests of the seeds of birdsfoot trefoil is the tarnished plant bug. Work on its control was continued during the past year. GC3707, Diazinon and Bidrin all gave control comparable to endrin. Bidrin was particularly effective. Lindane, GC3707 and SD7438, if applied early, at dosages as low as 2 ounces per acre gave good control of the tarnished plant bug.

Experiments designed to determine border effects and those of drift indicated that spray drift can affect insect populations over 75 feet from the sprayed plot. Insect movement had less importance than insecticide drift on insect populations.

A single species of long-horned grasshopper, Conocephalus brevipennis was found in large numbers in fields of birdsfoot trefoil. Investigations were initiated on its biology, bionomics, and behavior. Caged "singing" specimens placed in field plots appeared to reduce the number of free singing males in the plot.

Title: EUROPEAN CHAFER INVESTIGATIONS

Leaders: R. J. Little, Jr. and George G. Gyrisco

Of 9 new insecticides tested for the control of the European chafer grubs, Bayer 25141 showed the most promise. Chlordane at 8.0 pounds per acre continued to provide control after 12 years attesting to the long persistence in soil of this material. Three years after application of dieldrin and Telodrin at 3 pounds per acre and thiodan at 2, there were residues of 0.40 p.p.m., 0.37 p.p.m. and 0.05 p.p.m. respectively.

Studies of flight of the European chafer were continued in the modified environmental simulator. Wave length of diffused light appeared to be a dominant factor in flight response. A marked reluctance of chafers to fly was observed when time of flight was offset by 9.5 hours. A comparison of different rainfall (0.25 to 1.5 inches) administered at two preflight times, (2:00 p.m. and 7:00 p.m.) showed no significant effect upon evening flight. Tests designed to detect the response of chafer adults to simulated air temperature gradients of varying magnitude under lighted and darkened conditions revealed a tendency to move toward the lower temperatures as the magnitude of the gradient increased from 0° to 20°F. The presence of light intensities of 10 foot candles appeared to increase chafer adult activity.

Title: INSECTICIDE RESIDUES ON FORAGE AND IN MILK

Leaders: D. D. Hardee and George G. Gyrisco

Alfalfa treated with 4 ounces of dimethoate resulted in residues of 0.02 p.p.m. in 6 days. With the application of one pound per acre of dimethoate residues of approximately 0.35 p.p.m. were present after two weeks. All residues were on a green weight basis.

Dimethoate was fed to Jersey cows at 0.28 mg/Kg and twice this level for 14 days. Samples of whole milk (paper chromatograph) showed concentrations of less than 5-10 p.p.b. (or the sensitivity of the analytical method). No depression in cholinesterase activity of whole milk was detected during the feeding period. All cows remained normal and healthy as determined by medical examination of a veterinarian.

Title: BIOLOGY AND CONTROL OF THE ALFALFA WEEVIL

Leaders: E. J. Armbrust, W. R. Cothran, R. J. Prokopy and George G. Gyrisco

Alfalfa weevils exposed to an 8, unlike a 12-hour day are said to have abbreviated diapause in the laboratory. Weevils were reared starting from eggs and each of the four instars up through initiation of egg laying of the new adult females under simulated field conditions of temperature and humidity but varying lengths of light (8, 9, 10, 11 and 12 hours) in photoperiod chambers. There were no real differences between lengths of diapause in the various groups. With this work on diapause, work on a cabinet with different photoperiods, constant humidity jars and constant temperature is now underway in which assorted combinations of photoperiods, temperatures and humidity can be used in a study of diapause.

With sticky board traps, three apparent flight periods of the weevil were noted in 1963 of which the June-July peak was the greatest studied. There appeared to be little correlation between soil temperatures at the surface, soil moistures in the first inch of soil, density of larval and adult populations, amount of foliage present and weevils migrating. Significantly fewer beetles, however, migrated from alfalfa that was in good succulent condition throughout the feeding period (about 3 weeks) of the adults, but regardless of the excellence of the conditions approximately 70 percent of the weevils moved from the fields during the summer months. Migration usually occurred 25-30 days after adult emergence from pupae.

Chemical and biological controls in 1963 primarily stressed timing, formulations and residues. Fall and spring egg laying plus adult movement in the fall greatly influenced the success of chemical controls. Fall treatments giving greatest reduction in spring egg laying were the most effective. The data indicate a good correlation between the number of fall laid eggs and larvae collected in May but little between fall laid eggs and numbers of larvae collected in early to mid-June. These larvae came from spring laid eggs. The most damaging populations were found in June, being 23 times greater than the earlier May populations and were most effectively controlled by late fall applications.

Emulsions in the fall were found to be superior to granules when heptachlor, dieldrin and Telodrin were compared. Heptachlor in the fall was superior to Imidan, endrin, Sevin, Diazinon, lindane and Bayer 29493. On first cutting stubble, lindane at one-half pound was better than Imidan, Diazinon, Bidrin, Ciodrin, Guthion, SD-8530 and SD-7438. Bathyplectes curculionis and Tetrastichus incutus larval parasites were liberated near Ghent, N. Y. in cooperation with the USDA.

Alfalfa samples for residue analysis were taken of the fall treatments of dieldrin, heptachlor and Telodrin.

Title: A STUDY OF THE SOURCES AND CONTROL OF NUTRITIONAL LOSSES OCCURRING DURING THE HARVESTING AND STORAGE OF HAY AND SILAGE

Leaders: M. J. Wright and D. L. Linscott (ARS)

Analyses of samples prepared in 1961 and 1962 were continued. The chromatographic separation of organic acids was the principal technique used for macroconstituents, while gas chromatography was employed in detecting residues of herbicides. New work included preparation of oat silages at various stages of development of the crop (boot, heading, milk, dough, hard dough) and various degrees of dryness (as is, 70 percent, 50 percent moisture). Samples were drawn after 5 and 20 days and analyzed for pH, butyric, propionic, acetic, formic, lactic, and succinic acids. Analyses were not complete but appeared to confirm earlier results with hay crop silage.

Cooperation with pesticide residue studies led by D. L. Linscott and with forage quality studies led by G. W. Trimberger was continued.

Title: INFLUENCE OF AGRONOMIC PRACTICES ON THE NUTRITIVE VALUE OF FORAGE CROPS

Leaders: M. J. Wright, W. G. Monson (ARS), K. L. Davison, W. Hansel, K. McEntee and L. P. Krook

Grazing Trial

Eighteen steers grazed replicated blocks of 10 grass-alfalfa mixtures for the third successive year. Stands and agronomic yields were maintained at a satisfactory level but there was considerable loss of alfalfa in the alfalfa-orchardgrass mixture. Estimated digestibility, based on fecal nitrogen, tended to be influenced more by date of grazing than by mixture. Estimated intake, based on daily dosage with chromic oxide, has consistently been unreasonably high. A rapid method of measuring the chromic oxide content of feces through x-ray spectrography has been developed in cooperation with V. A. Lazar, U. S. Nutrition Laboratory.

Nitrate Studies

The effects of environmental temperature during growth on nitrate reductase activity in extracts of oats, orchardgrass, timothy and smooth brome grass have been studied. Timothy extracts have been devoid of activity at all temperatures tested; maxima for others were: oats, 60°F; orchardgrass and brome grass, 70°F. Studies on corn grown in low-concentration nutrient solutions have been continued.

A second group of 20 Holstein heifers has been fed nitrate at the levels of 0, 440, or 660 mgm NO_3^- /kg body weight, for periods ranging from 4 to 11 months prior to calving and one month thereafter. An additional group of 5 heifers was fed nitrate at the 660 mgm level beginning one month before

calving. Among the entire group of 45 heifers so far employed, two died and one was near death twice; all were receiving the 660 mgm level. There were three abortions, two at 660 and one at 440 mgm. No changes due to nitrate were observed in the estrus cycles, vitamin A nutrition, thyroid function, birth weight of calves, or milk production. Only traces of nitrate could be found in milk or meat.

When high-nitrate forages (corn, oats, alfalfa, redroot pigweed, lambsquarters) were grown or artificially prepared and fed to 25 bred ewes, nothing attributable directly to nitrate was observed, although the animals were not so uniform at the start of the trial as was desired. What are believed to be the first cases in Cornell flocks of hydrops and toxoplasmosis in sheep were observed during this trial.

Title: RECORDING FIELD OPERATIONS AND OTHER SEASONAL EVENTS IN
 AGRICULTURAL LANDSCAPES THROUGH REPEATED AERIAL PHOTOGRAPHY

Leaders: M. J. Wright, H. E. Conklin, G. A. Swanson and F. W. Young

An aerial photographic study of a strip of land 74 miles by 1.7 miles in Jefferson County, New York, was undertaken in 1963. The primary objective was to obtain an accurate record of the cropping practices and problems in the strip, which was so located as to include major soil associations, village and rural areas, and various wildlife habitats. Flights were made over the entire strip on May 15, June 16, August 20, and September 15; segments of the strip were photographed in color on June 23 and August 27, in infra-red on August 25, and from low altitude on June 17. Continuous activity by ground personnel made possible a comprehensive annotation of the photographs, and this in turn permitted the participants to acquire skill in interpreting the photographs.

Agronomy, Agricultural Economics, Conservation, and Rural Sociology at Cornell and the County Extension Service, the SCS, and the State Department of Fish and Game are using the same photographs, and assisting each other in various ways.

Preliminary summaries confirm that this technique provides a wealth of information on haymaking dates, distribution of weeds, density of stands of crops, length of rotations, and certain soil management problems.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF PERENNIAL FORAGE LEGUMES

Leaders: R. W. Cleveland and J. L. Starling

Alfalfa

(1) Nurseries established for breeding creeping-rooted alfalfa were maintained and evaluated. Good expression of creeping-rootedness and other plant characteristics occurred during this growing season and plants for further breeding experiments could be selected. About 100 plants were selected and removed to the greenhouse to be self-pollinated and intercrossed in groups of similar plant type. Plant types ranged from very decumbent to upright growth, and the different types are expected to be useful for different cultural purposes (pasture vs. hay production).

(2) Performance of 67 polycross progenies, derived from clones developed by USDA personnel, are being studied in a field trial established in 1963. Parents of the present lines were developed from Vernal and are resistant to leafspot, black stem, and bacterial wilt. The trial is for the evaluation of general combining ability, and for the determination of the relationships between forage and seed yields. The trial will be managed cooperatively with USDA personnel of the N. E. Regional Pasture Laboratory.

(3) Evaluation of varieties at several locations in Pennsylvania was continued. New experiments for testing recently introduced varieties were established at two locations. Several new varieties appear to be adapted for use in Pennsylvania. Those which we have adequately tested have been recommended for farm use.

Red Clover

Backcross breeding is being used to introduce resistance to Northern Anthracnose into the Pennscott variety of red clover. In 1963 BC₂ plants were intercrossed in preparation for inoculation of the progenies with the fungus. Adequate seed was produced for this phase of the program. A third backcross will follow the selection of resistant plants from the intercross generation.

Plant Introductions and Variety Trials of Miscellaneous Legumes

Field nurseries of introduced strains of alfalfa and birdsfoot trefoil, and variety trials of red clover and ladino clover were established in 1963. Previously established variety trials of several species were harvested for forage yield this year.

Title: CYTOGENETICS OF FORAGE CROP SPECIES AND INTERSPECIFIC HYBRIDS

Leaders: J. L. Starling and R. W. Cleveland

Trisomics in Diploid Alfalfa

Over twenty trisomics ($2n = 17$) were selected from the progenies of $3n \times 2n$ crosses. There were 110 plants in these progenies and chromosome counts were obtained from over half of them. Besides the single trisomics, four double trisomics ($2n = 18$) were found and five tetraploids. The remainder were all diploids.

Some of the trisomics showed slight abnormalities such as missing floral parts, two florets per node on a raceme, vestigial leaflets, notched leaves, and others. It has not been determined whether these abnormalities are caused by the trisomic conditions or are due to genes segregating in this material.

At present, emphasis is being placed on a study of the meiotic behavior of the 17- and 18- chromosome trisomic plants. Observations of a few of the 17-chromosome plants, showed the extra chromosome was most frequently unpaired at metaphase I but occasionally was found in a trivalent association, and more rarely the whole trio of chromosomes was found as three univalents. Irregularities involving other chromosomes have also been noted in some plants (extra unpaired chromosomes, chromosome fragments, anaphase bridges). The latter irregularities remain unexplained and the subject of future investigations.

Species Hybrids in Phalaris

A study of embryo-sac development has been completed in an MS thesis by Mr. T. Devine. This study was an attempt to identify the causes for differential crossability of Phalaris arundinacea and P. tuberosa. It was found that no discernible development of embryo or endosperm occurred when P. tuberosa was the female parent in the species cross. When P. arundinacea was the female parent considerable, but abnormal, endosperm developed, and the embryo was retarded.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: J. L. Starling and R. W. Cleveland

Orchardgrass Breeding

(1) Yields were obtained for the third year for restricted polycross progenies of parental clones in two synthetics, the Syn 1 generation of the synthetics and check varieties. One experimental synthetic produced a significantly higher yield than the best check variety. (2) New variety trials were established at two locations.

Timothy

Variety trials were established at two locations.

Reed Canarygrass Breeding

(1) A spaced planted nursery was established for grazing, using materials from eleven European sources and five F₁ inter-specific hybrids between reed canarygrass and hardinggrass. Acceptability of replicated plants by grazing stock will be rated and if consistent differences are found an effort will be made to relate acceptability to chemical constituent levels. (2) Variety trials were harvested and new trials were established at two locations.

Title: ROOT AND CROWN DISEASES OF FORAGE LEGUMES

Leader: H. B. Couch

The roots of field grown red clover and alfalfa were found to be infected with Fusarium roseum, F. oxysporum, and F. solani 5 weeks from the time of seeding. At this time, no evidence of root breakdown was visible. Pathogenicity tests were conducted with over 100 isolates of these three species. Several isolates of F. solani were found to be capable of inciting a cortical rot in 8 weeks old alfalfa seedlings. Fusarium oxysporum was also found to be capable of inciting a cortical rot in red clover and alfalfa seedlings. Two greenhouse trials were conducted to determine the influence of various combinations of these three species at different soil moisture stresses on severity of root deterioration. No correlation could be established between species combinations and effect of moisture stresses on root disease development in the readily available range. A series of studies on the influence of free amino acid and vitamin root exudates on the parasitic capabilities of these 3 species has been initiated. Red clover and alfalfa have been grown at varying soil moisture stresses between saturation capacity and the permanent wilting percentage and the eluted root exudates are now being processed for quantitative and qualitative free amino acid and vitamin content.

Title: EVALUATION OF SORGHUMS, SUDANGRASS AND MILLETS FOR PENNSYLVANIA

Leaders: J. B. Washko, J. D. Harrington and A. L. Haskins

Sudangrass, sudangrass-sorghum hybrids and forage sorghum for comparison with corn for silage experiments were grown at Centre Hall, Landisville and Ligonier during the past year with the following results:

The sudangrass-sorghum hybrids produced more forage per acre than either the open-pollinated varieties or sudangrass hybrid varieties. Average sudan-sorghum hybrid yields over the past 3 years at Centre Hall, Pa. were 4.63 tons of dry matter per acre compared with 3.05 tons for the true sudangrasses,

open-pollinated or hybrid varieties. At Landisville these yields were 6.02 and 4.17 tons per acre respectively and at Ligonier 3.53 and 3.00 tons. Differences between the true sudangrasses and the sudangrass-sorghum hybrids in feeding value calculated as T.D.M. from chemical composition were minor.

The first growth of sudangrass-sorghum hybrids compared with Piper sudangrass and two sudangrass hybrids was found to be higher in HCN content than that of true sudangrasses. At Centre Hall, Piper sudan was non-toxic (50 Mg./100 g. D.H. or over is considered toxic to ruminants) when harvested at 12" to 14" plant heights or above. At this same location, one of the true sudan hybrids appeared poisonous at the 18" to 26" height but not at the 12" to 14" height. The other true hybrid ranged from 44 to 48 Mg./100 g. D.M. in HCN. At Centre Hall 6 of 9 sudangrass-sorghum hybrids contained toxic levels of HCN at the 12" to 14" plant height and all 9 contained toxic levels at the 18" to 26" plant heights. Aftermath of these summer annuals contained less HCN than the first growth. At Centre Hall neither Piper sudan nor the two true sudan hybrids had toxic levels of HCN in their aftermath. While the aftermath forage of the sudangrass-sorghum hybrids was lower than the first growth, several of the sudan-sorghum hybrids had toxic levels of HCN in this regrowth when sampled at 12" to 14", 18" to 20", and 24" to 26" heights.

At Landisville the HCN content of all varieties was higher than at Centre Hall in 1963. Even the first growth of Piper appeared toxic at the 12" to 14" height but outgrew it by the time it reached 18" to 26". Both true sudangrass hybrids and all sudan-sorghum hybrids had toxic levels of HCN at both 12" to 14" and 18" to 26" plant heights at the first harvest at Landisville. However, the regrowth of Piper sudan and Trudan I, a hybrid sudangrass, did not possess toxic levels of HCN when sampled at 12" to 14" or 18" to 26" heights. The aftermath forage of 6 of the 9 sudan-sorghum hybrids appeared toxic at both 12" to 14" and 18" to 26" heights.

Differences in HCN content of these summer annuals at Centre Hall and Landisville cannot be explained solely on the basis of rainfall differences. Apparently other environmental factors are involved.

Recommended Pennsylvania corn hybrids produced more forage for silage than the forage sorghum at both Centre Hall and Ligonier. At Landisville the forage sorghums outyielded corn only slightly, with yield differences being statistically nonsignificant. Feeding value of the forage sorghums was inferior to that of corn. When sorghum forage and corn forage are compared on a calculated T.D.M. content basis 10 lbs. of forage sorghum are required to furnish the same amount of T.D.M. as 9 lbs. of corn forage on a dry matter basis.

When corn was planted at high populations for silage in single rows 25" apart and in double rows, 8" apart, on 35" centers at plant populations from 13,000 to 78,000 plants per acre the following results were obtained: lowest dry matter yields were obtained from the single row plantings at populations from 13,000 to 26,000 plants per acre. Double row plantings of 26,000, 39,000, and 52,000 plants per acre produced approximately the same amount of dry matter per acre (ranging from 7.70 to 7.89 tons per acre). Double row plantings at 78,000 plants per acre yielded 7.25 tons of dry matter per acre.

Highest grain yields were obtained at 26,000 plants per acre in double rows. At populations above 26,000 plants per acre grain yields in double rows exceeded those of single rows at the same population. Lowest grain yields, as would be expected, were obtained at the 78,000 plant population, 37.2 bushels per acre and the highest at 26,000 plants per acre in double rows, 115.1 bushels per acre. The chemical composition of this forage has not as yet been analyzed but it can be presumed that the forage with the highest grain content will have the highest feeding value.

Corn at those spacings and plant populations did not lodge in 1963. No trouble in harvesting was encountered nor was loss of forage experienced. Four double rows were harvested simultaneously with a forage harvester equipped with two-row harvesting heads.

Title: EVALUATION OF NEW FORAGE VARIETIES AND SPECIES FOR DAIRY PASTURES

Leaders: J. B. Washko, E. M. Kesles and A. L. Haskins

When nitrogen fertilized Pennlate orchardgrass, Viking birdsfoot trefoil-Pennlate orchardgrass, Vernal alfalfa-Pennlate orchardgrass, ladino clover-Pennlate orchardgrass and a succession of Balbo rye and Piper sudangrass were rotationally grazed with Holstein milk cows the following results were obtained in the second year of grazing: the alfalfa-orchardgrass produced the highest yields of dry matter per acre, 5.43 tons, the N-fertilized orchardgrass produced 3.78 tons, the birdsfoot trefoil-orchardgrass 3.00 tons, the ladino clover-orchardgrass combination 2.49 tons and the rye and sudangrass combined 3.12 tons. The nitrogen fertilized Pennlate orchardgrass had the highest carrying capacity in furnishing 455 cow days of grazing per acre, followed by 427 cow days for the trefoil-orchardgrass, 391 for the ladino clover-orchardgrass, 340 for the alfalfa-orchardgrass and 320 for the for the rye-sudangrass succession; five grazings, each, per season were furnished by the N-fertilized orchardgrass, the ladino-clover-orchardgrass and the rye-sudan succession, four by the trefoil-orchardgrass, and three by the alfalfa-orchardgrass.

These results indicate that dairymen can supply their cattle with a succession of high quality pasturage from April 22 to mid-October even in droughty seasons by utilization of several forage species that differ in maturity and productivity periods.

Title: ESTABLISHMENT AND MAINTENANCE OF BIRDSFOOT TREFOIL

Leader: J. B. Washko

The effect of different clipping management treatments on root reserves has been investigated with the following results: both the Empire and Viking varieties had high root reserves in the early spring when still

dormant. The lowest level of root reserves was reached in mid-June (1/4 the amount recorded at dormancy). Both varieties were at 1/4 to 1/2 bloom at this time.

When top-growth reached a 6-inch height on May 31 and was removed root reserves were depleted only slightly more than uncut plants. Later cuttings depleted root reserves much further. Reduction in root reserves continued for two weeks following forage removal before the trend was reversed.

The effect of forage removal at different stages of plant development on dry matter production was also studied in 1963. First harvests were taken when plants reached the pasture stage (6" in height), at 1/4 bloom and at 1/2 to full bloom (hay stage) with aftermath harvests removed every 3 weeks, 5 weeks and 7 weeks. Highest forage yields, 2.30 to 2.46 tons of dry matter per acre were obtained under the hay management treatment for both the Empire and Viking varieties. Lowest yields were obtained with the Viking variety when it was harvested every 3 weeks whereas for the Empire variety when it was harvested each time it reached a 6-inch height. When forage removal at 5- and 7-week intervals was compared, forage yields ranged from 1.56 to 1.78 tons of dry matter per acre for the Viking variety with yield differences between the two harvest intervals being nonsignificant statistically, irrespective, of stage of removal of the first harvest. Highest forage production with the Empire variety was obtained when this variety was subjected to the 3-week and 7-week harvest schedules. A 5-week mowing schedule imposed on this variety produced approximately 1/4 ton of dry forage less per season than the 3- and 7-week schedules.

Title: MAINTENANCE FERTILIZATION OF GRASSLANDS IN PENNSYLVANIA

Leader: L. F. Marriott

The 1963 yields of common orchardgrass topdressed with NPK ranged from 50 to 100% of previous averages as a result of differences in available moisture. Significant yield increases were obtained for nitrogen and potassium applications at all sites. Response to phosphorus ranged from slight to significant.

Limestone was topdressed in the spring of 1961 on two replicates of the orchardgrass experiment on Bucks silt loam. Soil samples taken in September 1963 ranged in pH from 4.2 to 6.5 in the surface 3 inches on the unlimed plots and from 5.6 to 7.3 on the limed plots. pH levels were closely related to nitrogen rate and carrier used, with ammonium sulfate at 200 pounds N per acre causing the greatest depression in pH. Available phosphorus as determined by the Pennsylvania State University Soil Testing Laboratory was increased 68% in the surface 3 inches as an average on the limed and phosphated plots. Available phosphorus at the 3"-6" level was not changed by the limestone application. Limestone did not increase available phosphorus where no phosphate fertilizer was used. Significant yield depression was obtained only where soil pH decreased to below 5.0.

Spring applications of nitrogen on 5 to 10 year old stands of orchardgrass were 10 to 40% more effective than October applications. However, there was no difference for time of application of the nitrogen on a new stand of timothy. This variability of response to late fall applications of nitrogen discourages recommendation of that practice.

Title: UTILIZATION OF FORAGE BY BEEF CATTLE

Leaders: J. B. Washko, P. J. Phillips and A. L. Haskins

Despite the droughty summer highest pasturage yields were produced by the tall growing grasses with 180 lbs. of nitrogen applied in four split applications of 45 lbs. of N each per acre. Dry matter production per acre for these grasses for the season averaged: reed canarygrass 4.4 tons, common orchardgrass 3.6 tons, S-37 orchardgrass 3.3 tons and Kentucky bluegrass 2.4 tons. Legume-grass pastures produced the following dry matter yields in tons per acre: alfalfa-orchardgrass and birdsfoot trefoil-Pennlate orchardgrass 2.9, birdsfoot trefoil-reed canarygrass 2.4, and birdsfoot trefoil-Kentucky bluegrass 1.5.

One-half of the pasture acreage was grazed with Angus and Hereford grade steers stocked at the rate of one animal unit/acre, the other half with two crossbred cow and calf herds (cows were a Holstein x Angus cross; calves were from these cows bred to polled Hereford or Charolais bulls artificially) and stocked at 2 acres per cow and her calf with and without creep feeding. In 177 days of grazing supplemented with grass silage made from these pastures 103 steers produced an average of 255 lbs. of beef per acre. If the pastures are credited with surplus silage produced but not fed out, calculated beef production from this silage would average another 24 lbs. per head or a total of 279 lbs. of beef per acre.

The average gain per crossbred calf for 20 head was 371 lbs. for the season with creep feeding and 365 lbs. without creep feeding. Sufficient forage was provided the two cow-calf herds by the pastures so that supplemental silage feeding was unnecessary. The crossbred calves averaged 2.04 lbs. gain per day compared with 1.37 lbs. gain per day for the steers.

RHODE ISLAND

Title: FORAGE CROP ESTABLISHMENT STUDIES

Leader: R. C. Wakefield

Effects of several herbicides and management factors were evaluated on a spring seeding of alfalfa. Good control of broadleaved weeds was achieved with 4(2,4-DB). Grass weeds were controlled by dalapon. The pre-emergence

herbicides EPTC, diphenamid, trifluralin and DCPA gave good grass control and fair broadleaved weed control.

Oats gave excellent yields of dry matter with good suppression of weed growth but caused reduction in alfalfa stands and size of plants. Nitrogen fertilizer stimulated weed growth, particularly broadleaved types, and reduced the effectiveness of dalapon and EPTC but increased the effectiveness of 4(2,4-DB). Delayed clipping of plots favored control of weed regrowth, particularly grass types.

VERMONT

Title: CHEMICAL CHARACTERIZATIONS OF THE NUTRITIONAL STATES OF SOILS
FOR FORAGE PLANTS

Leader: J. L. McIntosh

Results of field and greenhouse studies indicate that many Vermont soils contain large quantities of phosphorus. Further studies indicate that this phosphorus is present as aluminum and iron phosphates and is available to legume plants. The Morgan's solution (sodium acetate, buffered at pH 4.8) measures the phosphorus potential by extracting a portion of the readily available phosphorus in soils but does not extract phosphorus from aluminum and iron compounds. On the other hand, a solution of ammonium fluoride will remove phosphorus from these compounds in soils. A soil test procedure which permits the determination of the quantity as well as the potential of phosphorus in soils has been developed and preliminary studies seem very promising. Further testing is necessary.

The Champlain Valley soils are predominantly clay. These clays are dominated by mica, interstratified material and vermiculites. Consequently, these soils contain tremendous quantities of potassium which slowly becomes available to plants. However, the sodium ion used in the Morgan extractant to replace exchangeable ions is highly hydrated and relatively ineffective in replacing potassium from the soil. The ammonium ion appears to be very effective as a replacing ion. A solution of ammonium acetate, buffered at pH 4.8, retains the desirable characteristics of the Morgan extractant while providing for a much more effective replacing of exchangeable potassium.

Research outlined above will be continued. The chemical nature of aluminum and iron phosphates in soils will be studied.

Title: RELATION OF FERTILITY TO CROP ESTABLISHMENT AND SOIL PRODUCTIVITY

Leader: J. L. McIntosh

Field plots of alfalfa designed to serve as basis for soil test correlations and fertilizer response curves were harvested three times in 1963. Tests of soil samples and alfalfa plants taken from each sub-plot were analyzed. There were definite responses to increasing increments of lime and phosphorus on clay soils; there appeared to be no response to potassium. However, on sandy soils there were definite responses to lime and potassium but hardly any due to phosphorus. The correlation of these data will result in better interpretation of soil test results and better fertilizer use.

Plots were established to determine the effects of lime, phosphorus, potassium and boron on trefoil seed production, winter hardiness and forage yields. Plots will be ready for harvest in 1964.

Title: FORAGE CROP INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leader: George B. MacCollom

The alfalfa weevil, Hypera postica, first detected in Vermont during 1962 was found throughout Bennington and Windham Counties. The 1963 surveys showed northward movement of 35 miles. Evaluation of control materials on experimental plots was initiated in the fall of 1963. Surveys and evaluation of control practices will be continued.

Title: EMBRYO CULTURES IN LOTUS

Leader: A. Gershoy

In the continuation here of studies of cultivation in vitro of excised embryos in the torpedo stage or of younger proembryos (1962 Annual Report, page 83) no success has been thus far recorded. The Norstog-Smith medium for barley, at pH of 4.85, alone or with various adjuncts (including casein hydrolysate) has not been more serviceable than modified White's medium to which vitamins and various adjuncts were added. However, the cultivation in situ in the pod, of proembryos from the early globose stages on, has been accomplished in genetically balanced species hybrids and, especially, in wild, autogamous species. A wide variety of media appears favorable, at an initial pH varying from 4.85 to 6.2 and with sucrose concentrations from 2% to 9%. With the younger proembryo stages, in the young pods, and accompanied by scanty endosperm, there is always a drastic reduction in the number of embryos to reach maturity. Thus it should be emphasized that, with increasing age of the proembryo, the concomitant development of endosperm and the

correlative increase in size of ovary, an increasingly higher percentage of embryos and endosperm attains maturity. When proembryos in very early cleavage stages are cultured in situ the majority disintegrate; a meager number grow to heart and early torpedo forms, often distorted and appearing emaciated, accompanied by feeble endosperm increase. Occasionally an embryo is found with expanding recurved cotyledons. It appears that genetic imbalance is a decisive variable: in attempted wide crosses, or species-incompatible cross-pollinations, when proembryos fail to continue growth on the plant, attempts to cultivate these in situ have been unsuccessful.

Title: THE USE OF HYBRIDS AS BRIDGING FORMS IN SPECIES-HYBRIDIZATION
IN LOTUS

Leader: A. Gershoy

Available 2- species hybrids amongst L. corniculatus, 2X and 4X L. uliginosus. 4X L. tenuis and 4X L. japonicus were used for synthesis of 3- and 4- species hybrids. In some instances indirect syntheses were more effective when the relevant two species could not be crossed directly. All of the female-fertile species hybrids, at the tetraploid, triploid and assumed aneuploid levels showed some degree of seed set. Complete male sterility (aborting microspore tetrads) was found in a selfed F₁ hybrid of 4X L. uliginosus and L. corniculatus. A male sterile diploid of the former species was also found. Self sterile species and species hybrids maintained this characteristic as indicated in unsuccessful cross-pollinations when emasculation was not practiced. Female sterility (early abortion of proembryos) was found in several 3- species hybrids whose pollen was quite functional as determined by pollinations. Disturbed meiosis characterizes the various categories of species hybrids. Data obtained from studies here, those of Dr. R. R. Seaney, ARS, and Dr. W. F. Grant at MacDonald College indicate that species hybridization in Lotus, for the purpose of syntheses of desirable genes, is less difficult to achieve than was tacitly assumed at earlier periods of study.

Title: COMPATIBILITY IN T. MEDIUM, ZIG-ZAG CLOVER

Leader: A. Gershoy

Hand self- and cross-pollinations of well over 8,000 florets, in clones representing various sources, indicate that this high polyploid species has a completely self-incompatible system. There appear to be at least two distinct S- allele loci. Generally, unrelated individual plants are reciprocally cross-compatible but exceptions occur; the basis for these exceptions has not been analyzed since crosses were made only of parent clones. F₁ seeds and some parent clones are available for distribution. Where marked irregularities in the postulated system of gametophytic control have been observed these seem to be attributable to factors of abortive

sterility common to individuals comprising a family. In phenotypically similar seedlings of a close-bred 100 plus years stand, in an isolated Vermont field, much more cross-incompatibility has been found than in out-crosses of these to plants from other sources. Accessory (B) chromosomes are present. Pairing of A chromosomes is strictly diploid. Multinucleate and polysporic tetrads are not characteristic of this species but varying percentages of abortive pollen occur. The incidence of self-incompatibility in this high polyploid species points to the absence of competitive interaction of S- alleles in the pollen.

WEST VIRGINIA

Title: ALFALFA BREEDING AND GENETIC INVESTIGATIONS

Leader: Valentin Ulrich

Research emphasized the serological characterization of Medicago spp. populations. The seed and root antigens of sixteen species of Medicago and seven M. sativa cultivars and selections were studied through homologous and heterologous reactions. Species and varieties differed to varying extents in their organ and species specific antigens. Information derived through further studies of this nature may provide specific electrophoretic and serological "fingerprints" of antigens for each cultivar and natural population of Medicago.

Vegetative propagation of M. sativa var. Vernal with sand cultures in polystyrene cups sealed in polyethylene plastic bags was successful. The study was performed without natural light (only fluorescent lighting) and without watering subsequent to the initial affusion. The innovation of simple sterile techniques for clonal propagation with artificial light and without intermittent watering should prove a useful technique for genetic, physiological and pathological studies.

Title: RATE AND TIME OF APPLICATION OF K FERTILIZER IN RELATION TO YIELD AND LONGEVITY OF ALFALFA STANDS

Leader: G. G. Pohlman

Yields were obtained from three experimental fields to which potassium fertilizers were added at varying rates and times. Yields were considerably reduced by the dry season at two of the locations, averaging only about two tons per acre on a shaly Litz soil at Wardensville and about three tons per acre on Wharton soil at Morgantown. Neither of these trials showed any consistent response to potassium applications. The available K content at the

beginning of the year was about 90 pounds per acre at Wardensville and about 200 pounds per acre at Morgantown. Point Pleasant on Wheeling soil having an available content of about 200 pounds per acre in the spring showed yields of 7495, 8117 and 8307 pounds dry hay per acre for the 200, 300 and 400 pound levels of available K per acre. There were no consistent differences resulting from time of application.

Title: THE PERFORMANCE OF SEVERAL ALFALFA VARIETIES GROWN UNDER
DIFFERENT CLIMATIC CONDITIONS, WITH EMPHASIS ON THE
INFLUENCE OF FALL CUTTING

Leader: G. A. Jung

Yields were severely reduced during 1963 because of drought. Six of eight locations had severe drought conditions sometime during the growing season. This was the first time since the experiment was initiated that the variety-fall management interaction was not significant. The response may have been modified because of lower yields. Total forage yields were reduced by 1.5 tons/acre compared to previous years.

Vernal was the highest producing variety and Arizona Common the lowest producing variety in 1963. However, the average yield of DuPuits was only slightly better than Arizona Common. Lack of persistence with DuPuits has been attributed to Fusarium species by Dr. E. S. Elliott.

Harvesting the last crop of alfalfa in late October produced the highest total yields of alfalfa and harvesting the last crop of alfalfa in September the lowest total yields. The alfalfa was severely injured at Point Pleasant with the late September management.

A study of the effect of cutting stands at different stages of maturation on a particular date during the fall was initiated to shed light on conflicting data obtained for the early September management in previous years. Another supplemental study initiated was a study of fall grazing (using sheep) in comparison to fall cutting. Cutting and grazing during four periods of the fall will be compared for their effects on yield and persistence of alfalfa.

Title: EXPERIMENTAL STUDIES IN FORAGE CROP INSECT CONTROL - 1963

Leader: C. K. Dorsey

Investigations in alfalfa weevil control involved fall and spring applications (spray and granular formulations) of a number of different insecticides.

Fall application of granular heptachlor, at the rate of 0.75 to 1.0 lb. (actual per acre) gave the best control of all methods or materials against the alfalfa weevil when applied by November 1. There was some indication of reduced efficiency of heptachlor, but it still produced effective control results in West Virginia.

Among the spring applications of accepted insecticides, Malathion at the rate of 1.0 lb. actual per acre, gave the best over-all alfalfa weevil control as compared with several other label-acceptable insecticides tested.

Experimental studies in the leafhopper-plant bug complex included the use of a large number of experimental and accepted insecticides (spray and granular formulations). The results of 4 years investigational work with these forage pests are being summarized at present and will be published in the near future.

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